PART II

STRENGTH, FLEXIBILITY AND INJURY PREVENTION

PHOTO 7.1—Fred Astaire jumping for joy. Copyright Otto Bettman / CORBIS, 1941. Reprinted with permission.

CHAPTER 7

Stretching, Flexibility and Movement

At the beginning of team practice, athletes commonly get together with their coach for a brief meeting. They then normally conduct a number of stretching exercises before running the day's primary workout. In the absence of sufficient discipline, young people will often turn this meeting, and the flexibility program, into a chitchat session. The resulting attention deficit is characterized by a lack of physical and mental awareness. Various stretching exercises are then performed imperfectly. In fact, the actual time spent on stretching might not be more than 25 percent of the time assigned to the task. Nevertheless, athletes will then conduct flexibility exercises to obtain full range of motion about their joints, and warm-up for at least a half-mile before performing a more thorough stretching routine. Generally, the athletes will assume a number of individual static stretching exercises, and perhaps even some contract-relax, or hold-relax Proprioceptive Neuromuscular Facilitation (PNF) stretching. The athletes then run the day's primary workout. Unfortunately, the training session will likely be conducted on a hard asphalt or artificial track surface. Afterwards, the athletes will perform another stretching session, but with the same lack of focus. Essentially, the same routine is repeated every day. As a result of common *unpractice* of the day, the athletes fail to enhance their flexibility and running technique.

Heredity, Education, and Experience

Our physical make-up and metabolism is largely determined by our genetic endowment. We are dealt our hand in life, and then do our best to play it. Human beings initially learn much through imitation. How we walk, talk, and even run can be the product of imitation. Individuals commonly have a cultural and personal blind spot to these largely unconscious, imitative habits. Some people walk with their toes pointed outwards, and others with their toes pointed inwards. And some athletes carry their arms high and close to the chest, whereas others carry them low and below the waist. Later in life, we may suddenly come to realize how much we speak and walk like one of our parents. Much of this behavior is self-taught and the product of informal education. Obviously, our technique can also stem from formal education, and how we were originally taught to perform an action. Experience is the product of action, and numerous repeated like actions create habits and neuromuscular stereotypes. In short, an individual's characteristic movements are a product of genetics, education, and experience. Unfortunately, part of this experience may include injury to the body and its movement patterns.

Neuromuscular Scar Tissue

An individual's biomechanics and running style sometimes reflects their history of injury. An adjustment once made to provide relief for an injury can replace an earlier and more desirable running technique. Robert Bly used the analogy of an invisible black bag to describe the subconscious psychological baggage that people often drag around behind them (Bly, 1988). Likewise, athletes sometimes drag behind them a black bag of physical and mental scar tissue from previous physical injuries. Unfortunately, after the injury has healed, the injured movement pattern can remain, and the affected athlete may have no kinesthetic awareness of this change. Athletes may believe they still move the same way, but in reality they do not.

Kinesthetic Sense, Lies and Video Tape

There can be a wide gap between what an athlete perceives concerning their running style, and what they are actually doing. An athlete's kinesthetic sense and mental image of their running style is generally a big lie. The fact that athletes run in protective footwear tends to decrease their kinesthetic sense of just where and what their feet are doing. Athletes commonly make biomechanical adjustments when running on various shoes and surfaces, and are not cognizant of these changes.

To remedy this situation, their level of awareness needs to be raised. They need to realize that there is a gap between their mental picture and reality. Given greater awareness, they can decide to do something about the discrepancy and close the gap. Athletes can stop themselves when they are about to make an error, and instead, make a conscious effort to perform the action correctly. Repeated actions form habits. Right habits of movement are biomechanical virtues. From a motor learning standpoint, this phenomenon is similar to the Pavlovian conditioned response, and the stimulus-response chains of the Behaviorist and Experimental psychologists (Pavlov, 1927).

This concept can also be found in the Alexander Technique, developed by F. M. Alexander in England (Alexander, 1995). Alexander found that the body's kinesthetic sense can indeed lie. He used the word "inhibition" to describe when an individual consciously stops and catches the body before it has a chance to commit another lie. Alexander used the phrase "directed activity" to describe the conscious performance of the activity in a proper manner.

Alexander realized that static positions and repetitive activities create strain on the body and cause it to become unbalanced. He understood that people use imitation in neuromuscular learning, and an individual's emotional distress can be imparted to the body and reflected in movement. Alexander taught the use of slow and reversible movements. When these were mastered, other actions could be performed with greater control, speed, and power. Alexander taught absence of effort—that is, only what needs to be done is done—and this was normally associated with slow and relaxed breathing. He recognized that end-gaining or outcome orientation could disturb the performance of an action. He then properly focused upon correct process—Alexander was an intelligent and progressive man.

The discoveries of Alexander came about due to his own inability to speak properly at a time when he was *desperately* trying to pursue an acting career on stage. In brief, he was outcome-oriented and literally choked. Like the ever-rational detective Sherlock Holmes, Alexander approached the problem or crime his body had committed by analytically observing the physical evidence. And in viewing the evidence, he recognized various physical phenomena and changed his bodily behavior. These changes in physical behavior brought changes to his basic mental outlook. Such was the nature of his path to enlightenment.

Today, someone like Alexander could seek the help of a good sports psychologist and focus on the primary problem, as opposed to the mere physical symptoms. Alexander would directly confront the problems associated with his outcome-oriented outlook. He would be instructed to recognize the physical and mental canaries. And he would be taught various methods of centering, relaxation, biofeedback, and how to successfully perform the desired activity in a manner not unlike what he eventually discovered for himself (For more on the Alexander Technique, see Alexander, 1995, and Drake, 1996).

Two things can be used to great advantage in wiping an athlete's slate clean of biomechanical faults and restoring sound running technique. One is the liberal use of videotape, which can prove invaluable for enhancing self-awareness. The other is walking and running barefoot on natural grass or sand surfaces. After starting to walk and run on grass, runners who have had injury problems for years and bounced from one doctor to the next without relief have come right in less than a month. There are many reasons why this works, but they largely boil down to one simple fact: walking and running barefoot on grass or sand is natural and normal. Asphalt and athletic shoes are relatively recent inventions, and they are not necessarily performance enhancing or healthy.

Faulty Surfaces Instill Faulty Technique

In the United States, athletes commonly run their primary training sessions on asphalt roads or the track. The road surfaces are normally hard, flat, and minimize turns or variations in elevation. Many roads incorporate transverse grades of five or more degrees to promote water run-off, and this can result in effective leg length differences. Athletes who run on asphalt tend to stagnate and habituate as a result of repeated motor actions. Instead of having to negotiate the nuances of surface variation, the body experiences sameness. Instead making frequent turns, the athletes might run in a straight line for miles. Instead of the challenge of rolling uphills and downhills, they experience the world as relatively flat.

Such extreme habituation and stagnation can develop into a certain stiffness and incompleteness in their movements. From the standpoint of motor learning, running on asphalt resembles what is referred to as blocked practice, as opposed to random practice—which takes place in a natural environment. Greater learning takes place when athletes experience random practice (Schmidt, 1988, and 1991). Further, when the body attempts to protect itself from shock loads, the biomechanical adjustments normally result in a shortening of the stride and less energetic application of force to the support surface. The athletes can become economic shufflers on the asphalt.

From the standpoint of mental concentration and focus, the continuity of the asphalt running surface and the monotony of the terrain can allow athletes to run without paying much attention to their biomechanics. They can, for the most part, run on automatic pilot. This can lead to muscular imbalances, injury and mental staleness. Athletes can't treat themselves like Pavlov's dog every day without starting to sniff, scratch, and bark at some point.

Running on natural terrain requires greater concentration, focus, and directed awareness. If athletes do not pay attention when running in a natural environment, they can easily trip or turn an ankle on a protruding obstacle. Running in a natural environment requires focus and one-pointed attention. The mind is absorbed in doing only what the body is doing. This oneness of mind and body is the *sine qua non* for physical and mental development.

Moreover, the enhanced cushioning effects of natural surfaces facilitate a fuller, more energetic stride, and higher oxygen demand, thus inducing a greater training effect. All things being equal, the better an athlete's running style, the less stretching and flexibility work he or she will have to do.

Proper Stretching and Flexibility

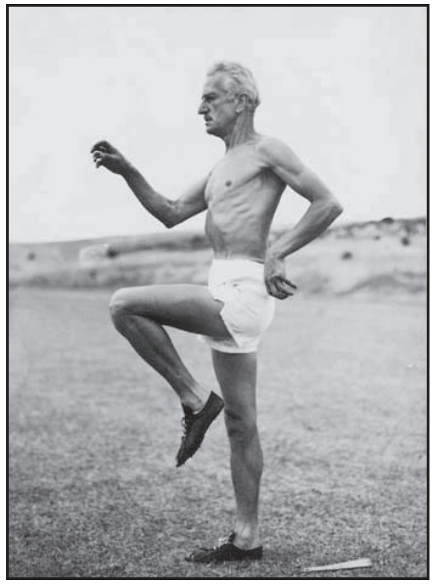
What constitutes correct stretching? Some might say to stretch like a cat and that is well. People do, in fact, stretch like a cat—that is, when they are not imitating a stretching activity they have seen or been taught. Think about how people stretch when they first awaken, as when lying on a couch. Their entire body moves in complete coordination. You cannot say there is a sequence of individual actions, rather, the entire activity happens together. Visualize how this happens:

Their feet alternately dorsiflex and plantarflex as they take a long deep breath. Then they subtly contract and relax the muscles of the lower leg, upper leg, buttocks, abdomen, back, shoulders and neck. Simultaneously, they raise their arms with the application of muscular contraction and relaxation, and move them asymmetrically as their head turns from side to side. And then they will slowly exhale with the sound of a yawn. It is as if their entire body responds to a continuous moving wave of muscular contraction and relaxation, just as a cat does when it first awakens. This is how human beings stretch naturally. Anything else is learned, and in that sense, contrived. Much of what is contrived is incorrect.

Conventional Stretching and Flexibility Exercises

How do conventional stretching and flexibility exercises rate? Is there a correct relationship or progression between different stretching and flexibility exercises? Ballistic stretching, that is, bobbing or forcing a muscle to stretch at a fast rate, is widely known to be ineffective and dangerous because it can induce injury (McAtee and Charland, 1993). However, this should not be confused with slow and deliberate stretching while moving the affected body part. Nor should it be confused with rapid actions that are the product of a progression of acquired skills.

Passive stretching, whereby the individual has a partner manipulate the body part to be stretched, also carries some of the injury risks found with ballistic stretch-



PHOTOS 7.2 & 7.3—The contrasting styles of rival coaches Franz Stampfl (left) and Percy Cerutty (right) are captured in these two photographs. The left photograph by Larry Burrows is from *Sports Illustrated*, November 26, 1956, page 84, courtesy of Russell Burrows; and the right photograph is from *Success: In Sport and Life*, London: Pelham Books, Ltd., 1967, and courtesy of Nancy Cerutty.

ing. These risks primarily stem from a possible communication gap between stretcher and stretchee. The presence of a partner can also result in numerous breaks in concentration. Given healthy individuals with full neuromuscular function, passive stretching is not advisable. However, if an individual has been incapacitated and cannot perform a stretching exercise, there is no other practical alternative.

Static stretching exercises are similar to learning the letters of the alphabet. They are a good place to start. Done properly, static stretching can accomplish basic stretching of targeted connective tissue including a muscle or muscle group. And static stretching can thereby enhance the athlete's flexibility consistent with the particular technique of a given static stretch. However, static stretching accomplishes little else. Muscles move in multiple planes, and one of the limitations of static stretching is that it tends to isolate only a single plane.

Proprioceptive Neuromuscular Facilitation (PNF) is more interesting since it uses what we understand to be natural stretching—that is, the kind of stretching that happens when we awaken from a nap. Hold Relax (HR), Contract Relax (CR) and Contract-Relax Antagonist-Contract (CRAC) more closely resemble how cats and humans stretch naturally. Single-muscle PNF stretching takes the letters of the alphabet—and is the first step towards forming individual words. When an individual applies muscular effort to affect the PNF single muscle stretch, a fuller stretch is possible. This is because of a greater recruitment of the affected muscle, due in part to subtle rotational movements. PNF stretching then becomes even more interesting when it turns to the use of spiral-diagonal patterns. Now an individual is forming words and even short sentences (Voss, et. al., 1985).

What Range And Quality of Movement Can The Unaided Individual Demonstrate?

The limitation of static stretching and PNF is that these activities are not sufficient to affect dynamic flexibility in the context of athletic performance. For example, in a seated static stretch of the hamstrings, athletes might be able to demonstrate an angle of less than 90 degrees between their torso and leg. But if they stand up and assume a normal vertical posture, then slowly raise their right leg as high as possible with their knee in a locked position, they may not be able to demonstrate even half of that range of motion.

When an individual maintains a normal posture of the head, neck and back, and conducts a slow, controlled movement of the limbs, pausing a moment to hold the maximum attainable position—that is their true range of motion and dynamic flexibility in the context of athletic performance. It certainly is not what they can attain during a static stretch with the assistance of a partner or a resisting surface. The range of dynamic flexibility that an individual can demonstrate in slow, smooth movements with proper posture, without any other means of support or application of force, approximates what they can exhibit when running.

For example, let's say that an individual stands up and assumes normal posture, then extends their right leg from the hip rearward with their knee nearly locked, and also moves their foot into plantar and dorsiflexed positions. Whatever they can exhibit when performing this movement slowly and deliberately approximates what they can exhibit when running. This is simple and fundamental, but unfortunately, sometimes not appreciated.

Dynamic stretching and flexibility movements are suggestive of the movements of great dancers. Arthur Lydiard and Percy Cerutty both held that distance runners could benefit by participating in dance at some point in their athletic development. The point is well taken.

Train the Whole and Get the Parts, Do Not Train the Parts and Miss the Whole

When athletes engage in dynamic stretching and flexibility exercises, many other aspects of fitness come into play. Their ability to balance, muscular strength, coordination, motor memory, learning, and neuromuscular inhibition all enter the picture. Some readers might have actually stood up and attempted to raise their leg in the positions described above and sensed that flexibility was not their limiting problem. They may have found themselves protesting that part of what the author suggested requires balance, part requires strength, and part requires coordination. And to hold the leg in a particular position for several seconds will require training in neuromuscular inhibition, and so on. That is right. That is precisely the point. The whole is larger than its parts. And unless you embrace the whole, the desired quality of flexibility will not be manifest during athletic performance. Our ego-conscious self prefers to slice reality up into many tiny pieces, but that is not the nature of reality.

If you cannot balance well enough to stand on the left leg and hold the right with almost a locked knee in various positions, then that is your limitation.

If you can balance well enough, but cannot hold your leg in a position for long due to a lack of strength, then that is your limitation.

If your agonist muscle sends a message to the antagonist to contract when a certain amount of tension or muscle fatigue sets in, then that is your limitation.

If your kinesthetic sense lies to you about your movements, then that is your limitation.

If you cannot perform multiple movements with grace due to a lack of coordination, then that is your limitation.

If you do not focus on an action, and perform it incompletely or badly, then that is your limitation.

Any number of possible combinations can determine an individual's range of motion and dynamic flexibility. The limitations of static and PNF stretching are that they do not address many of the above-mentioned phenomena.

> ***All things and events of the universe originate, co-exist, and integrate simultaneously, being correlated not only in reference to space, but also time. Hence the fundamental idea is simultaneity***
>
> —Dōgen Kigen

Making Words into Sentences into Poetry

If static stretching is the alphabet, and aspects of PNF stretching are words and short sentences, then poetry is something resembling a hybrid of *T'ai Chi, Yoga*, and the *Kata* performed in Karate. Is the poem better than the sentence, or the sentence better than a single letter of the alphabet? This is a nonsensical question, because these things are mutually interdependent.

T'ai Chi as a meditative movement teaches mental concentration and personal cultivation. The relatively vertical relationship maintained between the head, neck, and back while performing the movement is also consistent with the Alexander Technique. Some of the individual forms are appropriate for distance runners, but the historical evolution of T'ai Chi was heavily influenced by the martial arts, and so many of its forms are best suited to those activities. Further, T'ai Chi is not a stretching or flexibility exercise, at least not in the conventional sense.

The student of Karate often performs the Kata. The Kata is an exhibition of correct technique performed in a continuous manner so as to resemble dance. Sometimes the Kata is practiced at full speed and with considerable exhibition of power. However, the specific forms practiced in Karate are far removed from distance running.

The strongest teachings regarding stretching and flexibility are in the Yogic tradition. However, the Yogic forms and poses are seldom taught to comprise one continuous flowing movement as found in T'ai Chi or the Kata. The Yogic *Soorya Namaskar*, or Sun Exercise, perhaps comes closest to the type of sequencing, dynamic stretching and flexibility that would prove advantageous for distance run-

ners. There is an outstanding need to identify Yogic forms suitable for distance runners, and to choreograph them into a sequence that enables them to be performed in a continuous, flowing manner, as in T'ai Chi and the Kata—to comprise a suitable dynamic stretching and flexibility routine.

All three of the aforementioned disciplines teach essentially compatible and desirable breathing techniques. The following dynamic stretching and flexibility routine integrates all three traditions.

Dynamic Stretching and Flexibility Routine

The following dynamic stretching and flexibility routine includes numerous individual poses conducted in a sequence as part of one continuous exercise. While many might find this particular form suitable for themselves in daily practice, it reflects the author's own physique, age, experience and particular areas of weakness. Athletes are encouraged to try this particular routine for themselves, but also to create their own. In the light of circumstances, they might want to adapt their routine on a daily basis. The essential part lies in the principles and manner in which the routine is practiced, and not in a particular set of poses or sequence. However, in order to grasp the principles and basic technique, athletes can begin with the following routine:

Start by standing with your feet spaced normally, with correct posture (Photo 7.4). Take a relaxed, deep breath. Then slowly bend forward from the waist towards the floor with outstretched arms, and slowly exhale. Time your exhale to end at the lowest portion of the movement. Pause and retain your diaphragm in the contracted position for several seconds as you briefly hold the lowest portion of the movement, while still maintaining the integrity between the alignment of the head, neck and back. During this movement, slowly contract and relax the muscles of the toes, then legs, and so on up to the head and fingers, as when waking from sleep. This directed awareness and contract-relax activity should take place as you reach the maximum stretch in each and every individual movement within the routine (Photo 7.5).

Then inhale as you straighten up at a rate twice as fast as when descending. This should provide a ratio with respect to the duration of inhalation, retention, and exhalation approximating 1:4:2 (Swami Vishnu-devananda, 1988). Then, with a full breath in the up position, and no break in movement, bend from the waist backwards, gradually thrusting the hips forward and exhaling (Photo 7.6).

Recover to the upright position while inhaling, and then bend from the hip to the right while exhaling (Photo 7.7).

Then, recover to the upright position while inhaling, and do the same routine to the left (Photo 7.8). Then step into a wider figure "X" stance with the arms and legs outstretched, and repeat the above-mentioned forward, backward, and side-to-side movements (Photos 7.9—7.13).

Then, from the standing position, bend at the right knee and lower the torso over the right foot, leaving the left leg in the extended position and thereby stretch the adductors of the left leg (Photo 7.14).

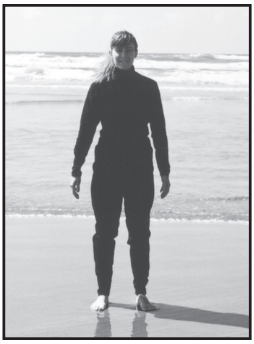
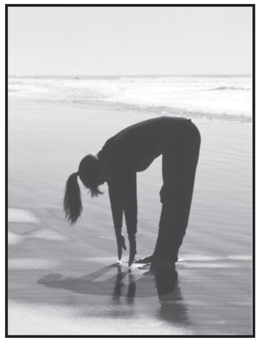


PHOTO 7.4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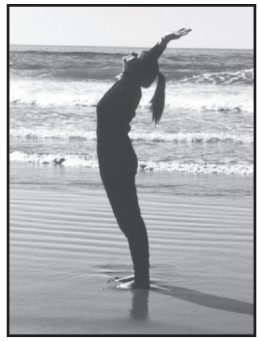


PHOTO 7.6


PHOTO 7.7


PHOTO 7.8


PHOTO 7.9

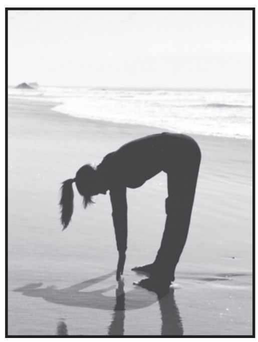
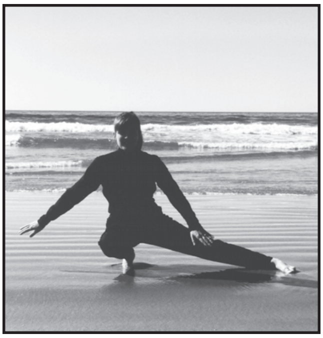


PHOTO 7.10


PHOTO 7.11


PHOTO 7.12


PHOTO 7.13



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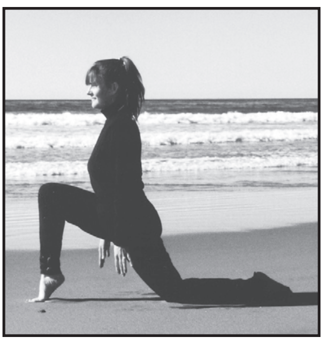

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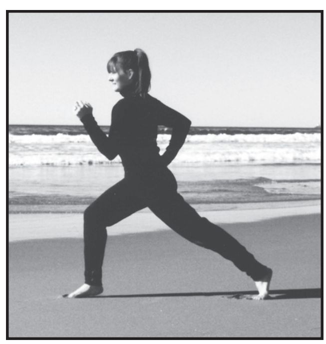


PHOTO 7.25

In all of these movements, exhale during the stretch. Then, as you achieve the maximum stretch, pause, holding the diaphragm in the contracted position, and inhale during the release. Conduct the muscular contraction and relaxation from toes to head (including the primary target group) in unison with the movement. Your arms can be raised to the sides and extended overhead so that the fingers of your hands touch at the maximum position.

Inhale while rotating the extended leg so that the foot points upward. Then exhale while bringing your arms towards the leg, and perhaps grasp the toes of the extended foot to stretch the hamstrings of the left leg (Photo 7.15). Next, inhale as you rotate your extended leg downward to again bear weight on the support surface (Photo 7.16).

Exhale while ascending from the weight-bearing right leg, switch over to the left, and exhale while lowering the torso in a similar manner over the left leg. Again, for balance and to help maintain a vertical alignment, your arms can be raised, extended, and the fingers of your hands can be locked over your head while completing the lowering motion. This will stretch the adductors of the extended right leg (Photo 7.17).

Then, inhale while rotating the extended right leg so that your right foot points upward, and exhale while extending your arms toward it, and perhaps grasp the toes of the extended foot to stretch the hamstrings of the right leg (Photo 7.18).

Then, inhale while rotating your left thigh from its perpendicular position (in relation to the extended right leg) to a position parallel and adjacent to the right leg. The ball of the left foot and the heel of the extended right foot remain planted during this movement (Photo 7.19).

Then, as you begin to exhale, shift forward on the extended right foot, which will then flatten on the support surface while the right knee rises. At the same time, lower the left knee to the support surface, and continue the forward movement until the left thigh extends rearward from the hip, and the right knee is slightly forward of the ball of the right foot (Photo 7.20).

Again, this is done in one continuous movement, and the position resembles a fully extended stride. For runners, this is a functional version of the splits, and it stretches the quads of the leg that has its knee bearing upon the support surface. You should exhale as you assume the forward extended position, and then simultaneously attempt to flex forward the rearward extended upper leg, which should nevertheless remain in the planted and fixed position. While executing this movement, you can raise both arms over your head and join the fingers of your hands.

Next, rise up on both feet enough to disengage the planted left knee, and then, while evenly bearing weight on the balls of both feet, rotate 180° (Photo 7.21). Then descend, bending the right knee, and sit over the right foot with your left leg in the extended position. This duplicates the position in Photo 7.19, but now for the opposite side (Photo 7.22).

Then descend on the right knee to conduct the same movement for that side, as described earlier. While attaining and retaining the forward extended position, exhale and hold the diaphragm briefly in the contracted position (Photo 7.23). Then

inhale while elevating the torso, and in so doing, raise the weight-bearing knee from the support surface so that the weight rests on the balls of both feet, thus moving into the position of a fully developed running stride. Then, as you move the knee of the rearward extending right leg to an almost locked position, exhale, and contract and relax the flexors of the rearward-extended leg (Photo 7.24). Next, pivoting on the balls of the feet, rotate 180° and reverse the relative position of both legs (Photo 7.25).

Then, perform the same dynamic stretching and flexibility movement for that side, as just described, with the breathing pattern coordinated with the movements. As you complete some of the individual dynamic stretching and flexibility movements, you might do the contract-relax stretch that happens when awaking from sleep, which travels in a continuous wave from toes to head and outstretched arms.

Having completed this progression in a slow, deliberate manner, athletes are usually quite flexible. While saving time is not a goal, this routine actually takes far less time than most athletes often spend doing disassociated static and PNF stretching exercises.

In order to enhance the effect of the dynamic flexibility exercise: Both before and after the above routine, the athletes should visualize the entire conduct of the routine. In particular, the athletes should imagine the external and internal movements of the body, and in particular, mentally project the desired practical effects. This is in contrast with the athletes' focus during the physical performance of the routine, when their attention should be directed to actual performance of the movements. One simple way to recall the sequence of movements in the larger routine is to visualize while mimicking the breathing pattern. This makes recollection easy.

There are a number of reasons for using visualization or imagery techniques both before and after physical exercise. The visualization exercise before the routine turns on the key—effectively starting and warming up the body. It is then possible to conduct the physical aspects of the routine more effectively. As athletes prepare to take strenuous exercise, they also warm up mentally and emotionally. The memories and emotions from previous experiences, step up the nervous system to an increased "tone." Done correctly, this helps to prepare the body for the demands soon to be placed upon it.

After the dynamic stretching and flexibility routine, athletes should again conduct the visualization routine because, as those familiar with the Feldenkrais method are aware, actual improvement is greater through visualization than through action (Feldenkrais, 1990). However, note that in the Feldenkrais teachings, so-called visualization is not merely visual. Rather, individuals are directed to imagine the sensory feelings and input associated with the actions, and to focus on the kinesthetic sense. Imagining what the action will *feel* like and noticing these subtle differences is more effective than visualizing the action, that is, merely seeing it.

Conducting the imagery routine after a dynamic stretching and flexibility session also serves to turn the key off—and quiet the mind and body. Otherwise, even after the workout, the athlete's mind and body might remain in a state of heightened readiness and activity. This phenomenon is well understood in Yogic teachings.

> ***More of our energy is spent keeping the muscles in continual readiness for work than in actual useful work done. To regulate and balance the work of the body and mind, you need to learn to economize the energy produced by our body, which is the main purpose of learning how to relax.***
>
> —Swami Vishnu-devananda

To turn off and cool down the body after exercise, athletes should lie in the Yogic corpse pose, flat on their back upon a supporting surface with arms slightly outstretched. They should then engage in relaxed breathing, and imagine their internal body parts and the intended action, while sequentially contracting and relaxing the primary target muscles of the body, starting with the toes and working up towards the head and arms. This completes the dynamic stretching and flexibility routine. When athletes observe this practice, they will find that their muscles do not tighten up so greatly in the hours following exercise. Otherwise, only a few hours later, they might find themselves less flexible than they were shortly after exercise. At a subliminal level, this can easily interfere with their ability to get to sleep.

Yoga

Almost every stretching pose imaginable is a part of the Yogic tradition and has therein been given a name. The previous dynamic stretching and flexibility routine can be considered a hybrid form of Yoga. A serious student of yoga will recognize that it begins with meditation, then flows to *pratikriya*, then to goal-oriented *asana* practice, then back to *pratikriya* and to meditation. However, many other Yogic poses and routines can be advantageous for distance runners. In this regard, the reader may see two fine books: *The Runner's Yoga Book*, by Jean Couch, 1990, and *Yoga For Wellness*, by Gary Kraftsow, 1999, which contains an excellent discussion of sequencing.

Distance runners should occasionally practice at least the following yogic forms: the cobra, dog, superman or locust, bow, triangle, Lord Nataraja, ankle-knee, open angle, head-knee, reclining hero, wheel, wind relieving, supine hand to foot, shoulder-stand, plough, and corpse poses. When performing a sequencing routine, it is relatively easy to transition from the cobra pose to the dog pose to the superman or locust pose, and then to the bow pose. Likewise, it is easy to transition from the wind-relieving pose to the supine hand to foot pose, to the shoulder-stand pose,

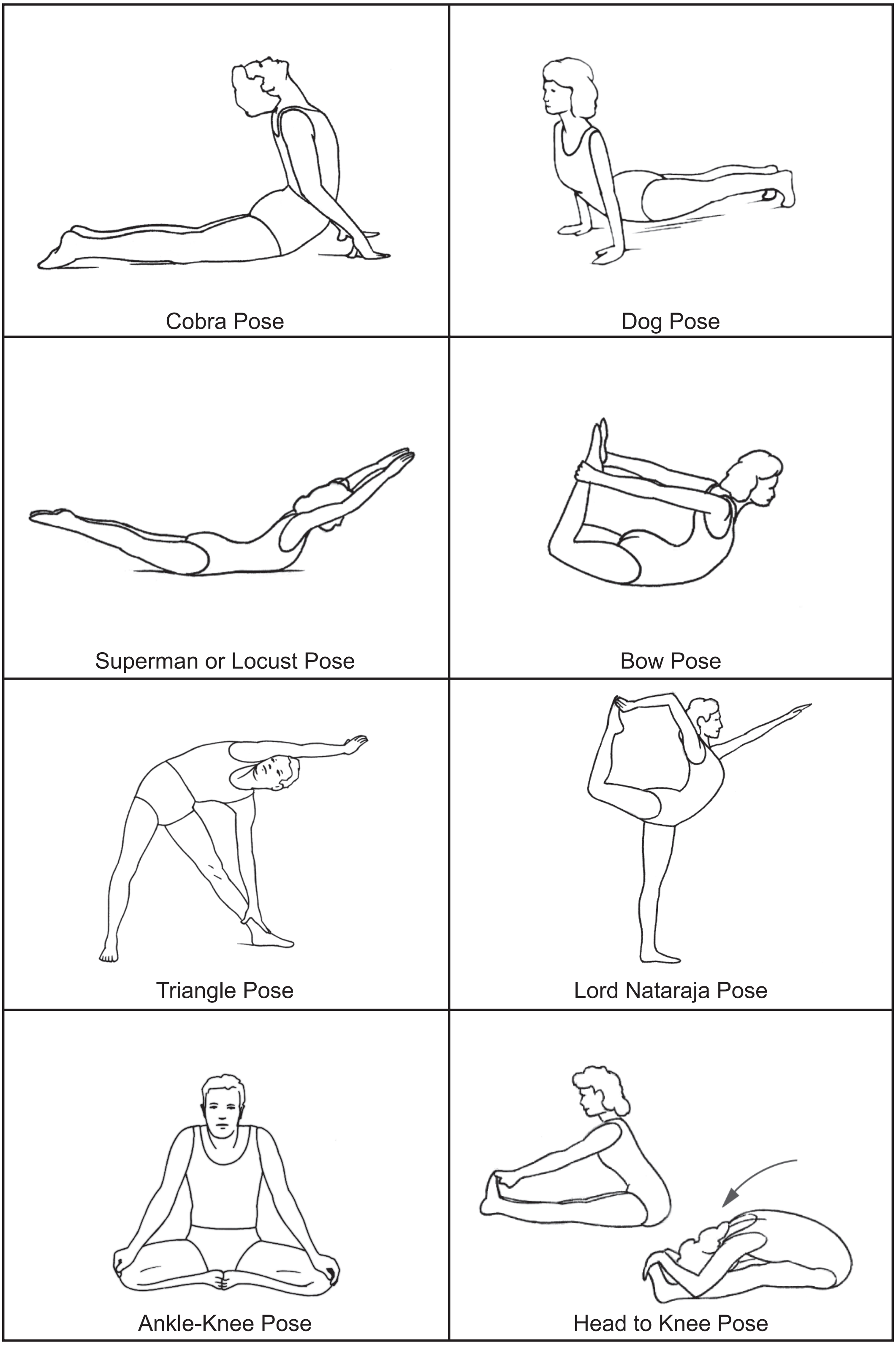
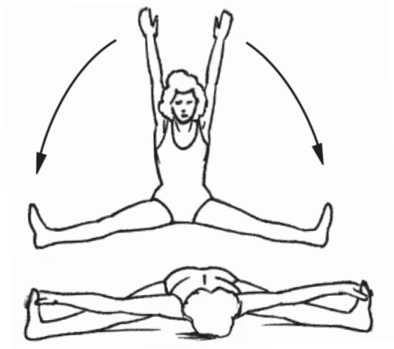


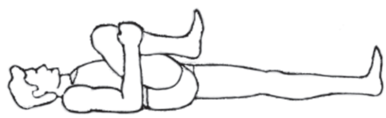
FIGURE 7.1—Yogic poses



Open Angle Pose

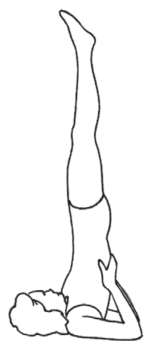
Reclining Hero Pose

Wheel Pose



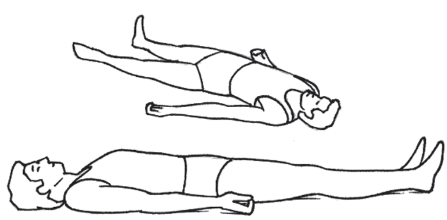
Wind Relieving Pose

Supine Hand to Foot Pose



Shoulder Stand Pose

Plough Pose



Corpse Pose

FIGURE 7.1 continued—Yogic poses

and then to the plough pose. To help clear the legs of the by-products of a hard workout or race, distance runners might wish to perform the shoulder-stand pose. Athletes should normally end a dynamic stretching and flexibility session in the corpse pose, lying flat on their back with arms slightly outstretched (See Swami Vishnu-devananda, 1988, Couch, 1990, and Kraftsow, 1999).

However, it is inadvisable for distance runners to perform extremely pretzel-like Yogic forms. They should not over-do things and stretch ligaments or tendons to such a degree as to cause injury. There is such a thing as being too tight, but also being too loose. Somewhere in between lies the golden mean. Athletes should progress so as to be capable of performing a series of Yogic forms in a continuous flowing manner.

Rehabilitation and Acquisition

Nevertheless, static stretching, PNF stretching, and the dynamic stretching and flexibility routine are not sufficient to fully rehabilitate an individual. Muscles are educated by movement, and repetition is the mother of learning. Rehabilitation of a movement pattern requires recreating a neuromuscular stereotype, and that entails a high number of repetitions. The process of rehabilitation therefore closely resembles the original *habilitation* process, and also acquisitive efforts directed to achieving higher levels of performance. Running faster or jumping higher also requires the creation of new neuromuscular stereotypes. And it demands a considerable investment of time and effort directed towards the repetition of a movement pattern.

Athletes generally have tight muscles and limited flexibility for a reason. Their inflexibility is normally the direct result of how they use a particular muscle group or limb. And all the conventional stretching and flexibility work in the world will not necessarily change their movement pattern. For example, athletes having tight quads are generally over-using that muscle group and under-utilizing their hamstrings. If they want to increase the flexibility of their quads, then they might need to do exercises such as walking squats to increase the strength of their hamstrings. Athletes also differ greatly in their ability to perform movements while in a state of fatigue. And during athletic performance they must manage not only high loads and rates of movement, but also the presence of fatigue.

Fatigue and Inhibition

If the coach instructs a group of athletes to stand on one leg and simply perform leg raises (that is, bend at the knee and raise the thigh parallel to the support surface), then return the foot while not quite touching the ground, some interesting things will be seen. When athletes are properly trained they can perform 100 reps, or so-called 100-ups. But what happens when a group of athletes have not been trained in this form drill? The first 10-20 reps are easy—but wait—by 30 reps it becomes difficult, and by 50 reps some athletes become bound up and incapable of maintaining anything resembling correct form. By the time they reach 60 reps some will drop out, and only a few will manage 100 reps. For some, the limitation is balance, for others it is coordination, and for still others strength. But something else is going on here as well.

Athletes vary greatly in their neuromuscular coordination, and also their relative inhibition between agonist and protagonist muscle groups. As athletes fatigue, the effort taken to recruit the agonist muscle can sometimes engage the antagonist as well. The muscle spindles and golgi tendon organs have their role to play in protecting connective tissue and facilitating movement. Nevertheless, the threshold of engagement for neuromuscular inhibition can be trained and elevated to enhance performance.

Further, when extreme fatigue is present, the neuromuscular system does not respond in the same way, nor do athletes accurately perceive their movements. For example, when finishing the last 100 meters of the 400 meters, their legs might feel heavy, sluggish, and not moving properly. Sometimes this is precisely what is happening, but sometimes that is only the way their legs feel. When properly trained, athletes might still feel their form breaking down, but they will correctly respond to that feedback and largely prevent it from happening. Learning how to interpret feedback and move with proper technique while in a state of fatigue is something of a whole new bag of tricks. In some sense, it is as if the athletes need to learn how to walk or run all over again. The possible gap between perception and reality needs to be made apparent so that they can close the gap in a constructive manner.

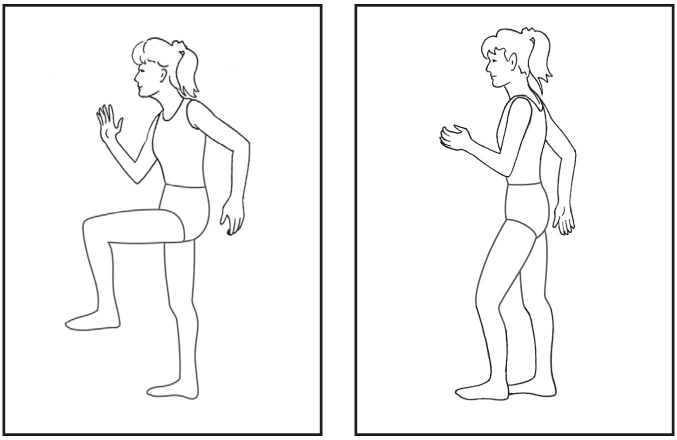
Stationary Form Drills

The medicine usually required is what some coaches refer to as form drills. The so-called “100-up” drill discussed previously is one example (See Figures 7.2 and 7.3). When it is conducted in front of a mirror, athletes can have immediate feedback regarding their movements.

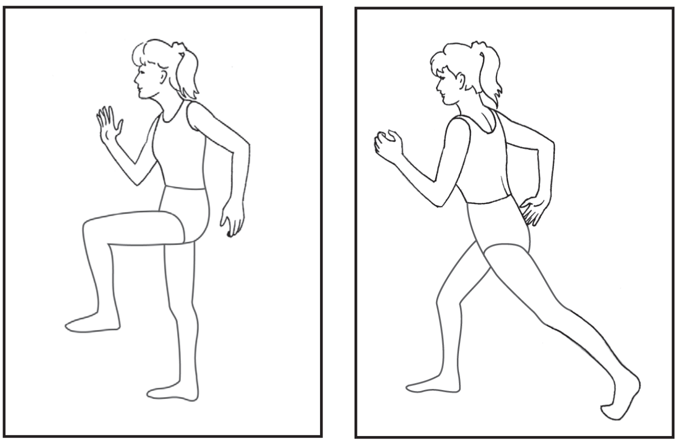
The late University of Oregon Coach Bill Bowerman used to teach a running form drill in which athletes stood on one leg while alternately raising and extending the opposite leg in a natural running motion, in synchronization with the opposing arm. Essentially, athletes perform the running motion while stationary on one leg. To steady themselves, they can initially stand with one shoulder against a wall, but should later perform the exercise in a freestanding position. Athletes should also progress to a point where their elevated foot only barely touches the ground, thus the muscles of the leg are not permitted to rest. Athletes can eventually progress so they can perform 100 repetitions non-stop before changing over to conduct 100 reps with their opposite arm and leg. In no instance should an athlete proceed if they cannot perform a form drill with complete control and perfect form (See Figures 7.4 and 7.5).

Again, when performing form drills, athletes need feedback, and in particular visual feedback. Their untrained kinesthetic sense can, and generally will, lie. What their body is doing, and what athletes think it is doing can be two very different things, but they may not be able to sense it. Athletes need to develop an accurate kinesthetic sense through repeated practice and observation.

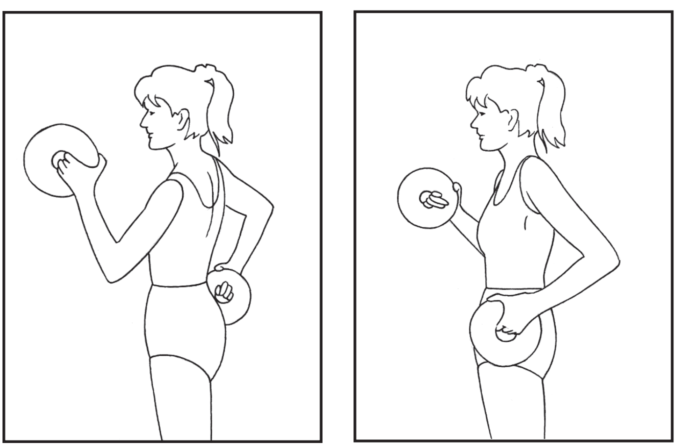
Another common stationary form drill includes arm swings—that is, holding light free weights in one’s hands and practicing proper arm movement for the duration of a middle distance race. This exercise should also include the transition in running form and arm action that takes place during the kick (See Figures 7.6 and 7.7).



FIGURES 7.2 and 7.3—up and down positions of the 100-up drill



FIGURES 7.4 and 7.5—up and down positions of the running form drill



FIGURES 7.6 and 7.7—up and down positions of arm swings

Another form drill is especially suitable for hurdlers and the steeplechaser. The athletes stand and raise their thigh parallel to the support surface directly to the side, imitating the up position when hurdling the barrier, and perform 50-100 reps. Hurdlers commonly practice several other different types of stationary form drills. For example, they will often stand beside a hurdle and repeatedly move their trail leg over the hurdle in a continuous circular action. If athletes do not perform a movement correctly and commit it to motor memory so that it becomes automatic during competition when they are in a state of fatigue, their performances will suffer. Errors would then occur, such as hitting a hurdle or steeplechase barrier. Stationary form drills focus on key specific movements that can improve an athlete's coordination, balance, strength, endurance, and ability to perform—even when highly fatigued.

Plyometric Form Drills

If an athlete cannot perform static stretching, PNF stretching, a dynamic stretching and flexibility routine, and simple stationary form drills proficiently, then they should not engage in more demanding plyometric form drills. Examples of plyometric drills are also provided in Chapter 8, and illustrated in Figure 8.1. Some of the drills used in circuit training by the Kenyan runners also comprise plyometric form drills (Abmayr and Kosgei, 1991). The only limit to the various possibilities is one's imagination. It can be advantageous for athletes to include specific plyometric form drills during their warm-down. For example, athletes can perform relaxed high-knee, alternating leg butt-kick, locked-knee, and also skip-bounding, as shown in Figure 7.8.

The introduction of music can solicit flowing movements and positive energy, as opposed to robotic movements (Matesic and Cromartie, 2002). Aerobics demonstrates the power of music in this connection. In truth, many aerobics classes include stationary and plyometric form drills. Movements having a desired training effect can also be conducted in the form of dance.

A Practical Stretching and Flexibility Program

What would constitute a sound daily training practice with regards to stretching and flexibility? Unless the temperature is over 60°, the athletes should be fully clothed. In order to attain a full range of motion, they should silently conduct a dynamic stretching and flexibility routine of their own design. This can normally be completed in five to 10 minutes. Thereafter, they should warm-up by running moderately for five to 20 minutes so as to break a sweat and attain a pulse of 120 beats per minute. Unfortunately, many athletes will have to wear athletic shoes and run a large portion of their training on asphalt roads. However, it is often possible to run the daily warm-up and warm-down barefoot on the infield grass of a track and field facility, or the soccer fields found at most high school and college facilities. The warm-up should then finish with a series of 100-meter accelerations, with a short continuous jogging recovery. This can be accomplished by running diagonals on the infield grass and jogging to the opposite corners. However, the coach and athletes should first carefully inspect the area for any debris that could possibly

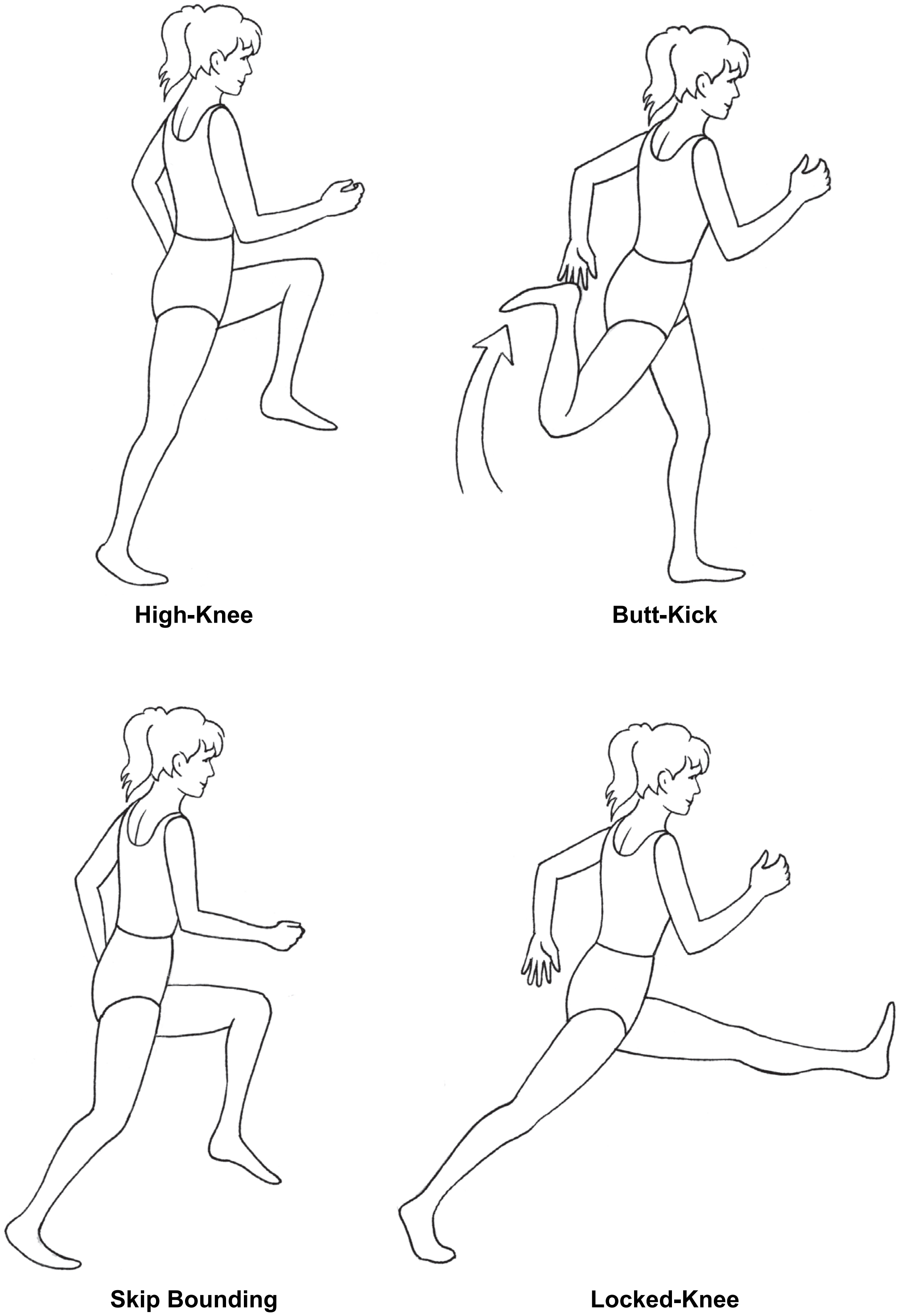


FIGURE 7.8—Plyometric form drills

result in injury. Even a relatively small amount of barefoot running can result in a visible improvement of an athlete's running style, and will often provide one second/400 meters improvement in athletic performance.

The athletes should then engage in whatever focused static, PNF, or other dynamic stretching and flexibility routines are deemed necessary to properly prepare themselves for the primary training session. Depending on the athlete's physical condition, and the nature of the training session, this second round of stretching and flexibility work is sometimes unnecessary. If a high quality workout is to be conducted, then the athletes should change into appropriate footwear and run at least three to six accelerations in the range between 50 and 200 meters. These accelerations or strides should gradually build up to, and slightly exceed the prescribed pace that will be undertaken. Athletes will then be ready to conduct the primary training session.

After completing the primary training session, whenever possible, athletes should run barefoot on a natural surface. Towards the end of their warm-down, they should conduct plyometric form drills such as high knee, locked knee, butt kicks, and skip-bounding. They should then put on warm clothes, drink water, and ingest a citrus juice or electrolyte replacement drink including a source of simple carbohydrates. Athletes should then perform a 20 to 30 minute 1/4-effort strength training session to restore equilibrium and facilitate recovery (as discussed in Chapter 8). On some days, athletes might even play a fifteen-to thirty-minute game of barefoot, non-contact soccer using a tennis ball. Alternately, they could play a few sets of tennis. These activities require brief accelerations and use the balancing muscle groups in lateral movements. All of the aforementioned post-exercise activities will restore equilibrium and speed recovery. They induce a shift in metabolism from catabolic processes associated with distance running towards anabolic processes and neuromuscular recovery. The athletes should then conduct various static, PNF, and dynamic stretching and flexibility exercises, including yogic forms, and finish in the corpse pose. They will then walk away from practice feeling pleasantly tired, in search of a good meal and rest, but not suffering from severe physical or mental exhaustion.

Running is the Ultimate Form Drill

The ultimate form drill is running on undulating natural terrain. The best movers are, in some sense, practicing flexibility with every stride they take. And the better their technique, the less remedial stretching and flexibility work will be required. The importance of cultivating good running technique becomes apparent when it is remembered that each day's running workout typically involves several thousand repetitions—as opposed to the relatively small number of repetitions associated with conventional strength training and flexibility exercises. The Australian coach Percy Cerutty wrote several books that address running technique and the importance of training in a natural physical environment (1961, 1964, and 1967). While difficult to locate, these books are highly recommended reading.

Cerutty sometimes worked an evening job that required little of his mental faculties. He then surrounded himself with his books, music, and barbells in order to make use of the hours. Likewise, Arthur Lydiard of New Zealand was a foreman in a shoe factory by trade, and sometimes also a milkman. These two individuals, who probably contributed as much as anyone over the last century to our understanding of training distance runners, were men of humble origins. They were largely self-educated and "the salt of the earth," rather than products of a celebrated university. Accordingly, they *earned* their knowledge through experience and reflection, allowing nature to be their guide.

Grace does not abolish Nature but perfects it.

— Thomas Aquinas

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PHOTO 8.1—The author's father, Bob Lyden, demonstrating the benefits of strength training, Camp Parks Air Force Base, Pleasanton, CA, 1953.

CHAPTER 8

STRENGTH TRAINING

Only the complete athlete finds success at the national and international levels. In championship competition few athletes can expect to be aerobically superior enough to sustain a pace none can follow. And in a race where the stakes are high, a front-runner cannot expect to drop all competitors with only surge and breakaway tactics. An athlete must be prepared for all this as a matter of course. The race goes to the complete athlete who can survive a testing pace, including surge and breakaway attempts, and still execute a winning drive to the tape. World class men in the 5,000 and 10,000 meters will commonly run the last 400 meters in under 56 seconds, and in the 1,500 meters nearer 52 seconds, with the final 200 meters in less than 25 seconds. That kind of anaerobic power and speed flows from strength.

Many of the training principles advocated by Arthur Lydiard of New Zealand have proven to be correct (Lydiard and Gilmour, 1962, and 1978). Nevertheless, there has been ongoing debate over the relevance of strength training to performance in middle distance and distance events. Lydiard is correct to stress that the number one limiting factor to performance in distance running is aerobic ability. However, some might mistakenly believe that the athletes who won fame under Lydiard were not exceptionally powerful men. The intensive hill phase that Lydiard advocates involves demanding resistance work, as does any running over the testing New Zealand terrain. Have a look at photos and film dating from the 1960's showing the build of Peter Snell. Americans watched Snell some years ago in the Superstars competition, and as his rowing demonstrated, he was still an extremely powerful man. So do not let the slender build of some distance runners fool you. Appearances can be deceiving. All things being equal, the race goes to the strong.

Distance running is a skill consisting of many components, and is not an activity sufficient unto itself for athletic development. Proper strength training can facilitate recovery from demanding endurance and sharpening work. It can enhance cardiovascular endurance, speed, and flexibility. Strength training can provide the durability and resistance to injury that figures so prominently in the longevity of an athletic career.

Exercise Physiology

A brief discussion of relevant exercise physiology will make it possible to later address a number of important questions relating to strength training and athletic performance. Strength is perhaps the most acquirable component of athletic fitness. Few possess the genetic gift, even allowing for an enhancement of 35% over their natural endowment, to permit them to become world-class distance run-

PHOTO 8.2—Peter Snell of New Zealand winning the 800 meters over Roger Moens, 1960 Olympic Games. Photo from AP/ Wide World Photos.

ners. And few possess the neuromuscular innervation and predominant muscle fiber type to become elite sprinters. But athletes can be stronger for the task of distance running than they ever need to be. Distance runners are not interested in muscular hypertrophy, but rather packing the highest level of strength and power into their competitive body weight. Many runners avoid strength training altogether, fearing cumbersome muscular development that would compromise their aerobic ability. However, this need not be a concern, given a properly constructed weight-training program.

Muscle Fiber Type

Muscle fiber has two predominant types:

- Slow-twitch (Type I) associated with endurance
- Fast-twitch (Type II) associated with explosive strength and power

Although some exercise physiologists suggest the possibility of muscle fibers splitting and replicating themselves as to type, our ratio of Type I and Type II muscle fibers is substantially fixed and genetically determined. At least three general sub-types exist within the fast-twitch muscle fiber type. These classifications between Type II muscle fiber types are based largely on biochemical rather than structural differences (Åstrand, 1986).

- Type IIa associated with ATP-Lactic Acid energy utilization
- Type IIb associated with the ATP-PC system
- Type IIc exhibits the ability to cross-train and assume many characteristics of the slow-twitch (Type I) muscle fiber

What does this imply for the training of distance runners? The genetic endowment as between the Type I and various Type II fibers does establish ultimate limitations. Some athletes are born for a given event. Certainly, this is true at the extreme ends of the spectrum, that is, the marathoner versus the sprinter, but things become much grayer as we move towards the middle distance events. In fact, by continually stressing a particular energy system and fiber sub-type amongst the Type I and Type II fibers, that particular type will develop and hypertrophy, whereas the other fibers types will remain the same or perhaps atrophy. The same number of fibers of the various muscle types still remain, but their relative development and proportional space utilization would change dramatically (Åstrand, 1986). Today, we can appreciate that the best performers at 800 meters are former specialists at 400 meters who have conducted the stamina work required to more fully develop their Type I, IIa and IIc muscle fiber metabolism. Table 2.1 (page 58) provides an estimate of the predominant energy system used in different events. The ratio of anaerobic to aerobic work would differ considerably between a mile run in 5:00 versus 3:45. The greater the speed, and the shorter the duration of the performance, the more anaerobic the event. And the more anaerobic the event, the more will Type II muscle fibers be utilized.

What are the wider implications of Type I and Type II fiber adaptation for distance runners? Athletes must train specifically for the duration and speed projected for the goal performance in the main race event. That is why Lydiard found it was not possible to simply train a 10,000 meters specialist for the 1,500 meters and thereby produce a high quality performance at 5,000 meters. The date pace and goal pace work done during the season educates the twitch to the proper tune.

With regard to muscle fiber composition, the natural athlete has an edge over the made athlete, since the latter must spend more time educating their metabolism to perform at a comparable level. This has more serious implications: When athletes cease their acquisition efforts, their muscle fiber type and metabolism detrains—that is, it heads back towards their natural endowment (Åstrand, 1986). For example, after the end of a season, an athlete genetically disposed to be a specialist at 800 meters will lose little form compared to another athlete genetically inclined to be a specialist at 3,000 meters, but who had nevertheless trained in order to achieve the same level of performance at 800 meters. The less specifically gifted need to train longer and harder to fool Mother Nature. That is one of the reasons why athletes need to recognize early and develop from the under-distance side towards their best racing distance.

The initial investment of time and energy in strength training can be substantial. However, athletes will find returning to a previously attained level of fitness far less expensive, and characterized by faster progression on succeeding attempts. And when out of form, they will also find a higher base level of fitness has been

established. The higher the level of fitness the athletes attain, and the more extensive their training background, the higher the base level of fitness that will be naturally maintained with less further investment. This is an important factor when it comes time to back off of strength training and concentrate on performance at the end of an athletic season. It is also important when developing to peak in a multiple year cycle such as one culminating in the Olympic Games. In this case, during the first years of acquisitive developmental work, athletes should engage in relatively energy-inefficient efforts directed towards their areas of weakness. In some sense, the athletes must fight Mother Nature to bring their apparent deficiencies up to certain minimums. This will later permit their natural line of strength to be fully exploited without the relative areas of weakness unduly restraining their ultimate performance potential. In an athletic season when optimal performances are desired, athletes should then train towards their natural strengths, and place special emphasis on quality in order to refine previously acquired powers. This will minimize any counterproductive macro-cycle (seasonal) and mega-cycle (multi seasonal) suppression of performance and permit optimal competitive results.

Strength and Muscular Endurance

Muscular endurance should not be confused with cardiovascular endurance. In the context of muscular endurance, an athlete who exhibits greater strength in a maximum lift will also normally exhibit greater muscular endurance in that exercise. For example, all things being equal, an athlete who can bench press 200 pounds will exhibit greater muscular endurance in reps with 100 pounds than another athlete whose maximum bench press is only 150 pounds. Of course, this assumes both individuals have comparable backgrounds with respect to training volume (the number of sets and reps being performed), since this would substantially determine the magnitude of local stores of muscle glycogen.

The popular notion that distance runners should do endless repetitions with light weights to improve their endurance is a lot of nonsense. Serious distance runners will be spending untold hours swinging their arms and legs in hundreds of thousands of endurance reps during weeks and months of training. They do not need to spend several hours a week flapping paperweights around. In any case, the maximum duration of an endurance weight training set would be the duration of the main race event.

In brief, distance runners should not cower away from high quality strength training or would-be impossible tasks simply because they may resemble the proverbial 138-pound weakling. And athletes should not lift light weights for fifteen minutes and fool themselves that they are doing something constructive. Distance runners should strive to become as strong as possible, but without inducing significant muscular hypertrophy or increasing their competitive body weight. Given their natural body chemistry, women need not be concerned about the development of unusual muscle definition or a resultant loss of sex appeal. In fact, the consensus among men is that just the opposite is true, and in this regard, female distance runners have the better deal over their male counterparts. For even after years of training, by all outward appearances, male distance runners might still beg having sand kicked in their faces—the bully making a big mistake!

Strength and Cardiovascular Endurance

The relationship between strength and cardiovascular endurance has not been fully explored by exercise physiologists. One effect of weight training is an increase in blood pressure to help perfuse working muscles, but this normally has little or no chronic effect upon the resting blood pressure. This temporary increase in blood pressure is largely caused by vasoconstriction, that is, by partially turning off the blood supply to relatively inactive tissues. The blood pressure is then raised so as to increase the perfusion pressure and blood flow through active tissues. This offsets the occlusion pressure and resulting impedance of blood flow caused by muscular contractions in the active tissues. The increased afterload on the heart from weight training (caused by resistance to pumping blood through working muscle tissue) induces concentric and ventricular hypertrophy, but without significantly increasing stroke volume or the ejection fraction. In short, the heart muscle becomes bigger and stronger.

In contrast, interval training increases the preload of venous return on the heart. This induces an enlargement of the heart and a corresponding increase in stroke volume (NSCA Journal, 1987). The heart then becomes more efficient, since it can pump more blood with fewer beats per minute (bpm). The practical result is bradycardia, or a slowing of the rest pulse rate—commonly observed in endurance athletes. Cardiac output figures largely in the formula of aerobic ability and the performance of distance runners (See Chapter 2, page 72).

Weight training can increase local stores of energy in the form of muscle glycogen, but if muscular hypertrophy results, the relative density of mitochondria (the powerhouse of the cell) could actually decrease due to a dilution effect. That could possibly compromise the aerobic ability of the athletes. In sum, weight training per se has little impact on the gross structure of the cardiovascular system. However, it has been determined that strength training can dramatically affect cardiovascular endurance by other means (Hickson, et al., 1988, Marcinik et al., 1991, Houmard, et al., 1991, Paavolainen et al., 1999). Strength training causes the body to generate higher levels of anabolic hormones, such as testosterone, which can generally promote acquisition and even increase the number of red blood cells. Further, if two athletes are placed on a treadmill, but one is much stronger than the other, the stronger athlete will demonstrate a less dramatic fatigue curve and will outlast the weaker. Generally speaking, stronger muscles fatigue slower than weaker muscles. The reasons for this defy an easy explanation, but they largely concern the so-called anaerobic threshold. In this regard, the higher level of fatigue in the nervous system caused by the weaker athlete's effort to manage the workload can be a contributor to early exhaustion. Further, the more forceful contraction of the weaker athlete's muscles to accomplish the same amount of work can result in greater occlusion, thus less adequate blood perfusion. The latter would result in a mechanical lowering of the anaerobic threshold. Less clear is how higher strength levels contribute at the cellular level to the use of fatty acids, carbohydrates and the removal of blood lactate. However, it has been found that some athletes learn to distribute the work load spatially, and then use more muscle mass while performing a task, thereby reducing the load on individual muscles (Coyle, 1995).

Strength training can significantly improve the technique and efficiency of distance runners. This ultimately determines just how much of their aerobic ability is ultimately translated into performance. The running economy of individual athletes can be tested on a treadmill and expressed as a percentage of their VO_2 maximums. If runners use a significant portion of their limited oxygen uptake on incidental movements (induced by muscle imbalances or weakness), the practical effect will be diminished performance. For example, athletes having weak plantar flexion at the ankle will tend to strike more heavily on their rearfoot. This often shifts their pelvis and center of gravity out of place, that is, substantially behind the point of footstrike. Thus the athletes must pull themselves forward, lift themselves up and across, and then push themselves forward from their center of gravity. That will use the larger muscle groups and incur a higher oxygen demand. By comparison, smaller and stronger calf muscles could have provided superior plantar flexion, and so would have consumed much less oxygen. This biomechanical adaptation would permit athletes to continually fall forward from their center of gravity and catch themselves with their next footplant. Athletes can have a deficient way of moving for any number of reasons, but when the problem stems from muscle imbalances or weakness, all the thinking or visualizing in the world will not remedy the situation. They have to do something about it, and that entails some form of strength training. Moreover, athletes should identify and eliminate their possible wobbles and whips in order to avoid injury.

Due to a combination of the above mechanisms as well as others, weaker athletes will cross their anaerobic threshold earlier (and possibly at a lower percentage of maximal oxygen uptake) than stronger counterparts. In practice, stronger athletes clearly demonstrate a marked advantage in arduous conditions. This becomes apparent when cross-country championships are held on demanding courses, and also when athletes confront headwinds or other adverse environmental conditions.

Speed and Strength

Speed flows from strength. The shorter the main race event, the stronger an athlete must be to compete at the highest levels. In this regard, there is need for greater force and power to be applied over time and space. In the middle distance events athletes require considerable anaerobic power, since the ATP-PC and ATP-Lactic Acid Systems provide the predominant energy source. This suggests the necessity for considerable strength training.

Athletes having greater strength in the appropriate muscle groups will demonstrate a longer stride, but will also be able to maintain more of their stride length during competition. A gradual shortening of stride length normally takes place during competition as athletes fatigue—this prevents an exorbitant slowing of cadence or stride frequency. The act of running can be divided for analytical purposes into a flight phase, and a support phase. Increases in speed are largely correlated with a decrease in the duration of the support phase. And a shorter support phase means that athletes must perform more work in less time, that is, they must dem-

onstrate greater power. The significance of the support phase for speed can be seen in the finish of many distance events. Some athletes invariably tighten up in the last straight and then seem to spend an eternity on the ground, thereby permitting their relatively light-footed adversaries to pull away.

The proper cue for athletes attempting a strong finish is to drop and quicken by slightly increasing their forward body lean while simultaneously lowering their hips. However, the actual increase in stride frequency and acceleration is initiated in the forefingers and is directed by the hands. Accordingly, the hands of the athletes should drop and drive below hip level as the change in posture is initiated, and then drive in a flurry with short, fast strokes relatively close to the torso, and reach nearly to chin level. Athletes never need think about their legs, since all else will follow the rhythm dictated by their hands (Cerutty, 1964).

All things being equal, stronger muscles are also more capable of rapid movement. Superior spatial and temporal neuromuscular recruitment and coordination (induced by strength training) plays an important role. If an athlete cannot perform a movement requiring maximal exertion slowly, then imagine how much less efficient the movement will be when performed quickly. Moreover, the stronger a set of muscles and connective tissues are throughout a requisite range of motion, the less inhibitory feedback will proprioceptors and protective sensors such as the golgi tendon apparatus send to turn off muscle groups via the reflex arcs. In brief, the body attempts to protect areas of weakness in a way that prohibits maximal exertion, thus resulting in a loss of power and speed.

Strength and Skill Levels

In order to maintain skill levels, stretching and flexibility work is always advisable following a strength-training session. However, activities including fine motor skills should also be undertaken. Otherwise, the skill level of the athletes could regress whenever rapid adaptation takes place. The same phenomenon can be seen when young athletes undergo a growth spurt—their skill levels drop. Because of this, including a skilled activity in the warm down is doubly important in those activities which require higher skill levels. For example, athletes can practice form drills, or jump rope after a weight training session. Free throw shooting can also help the athletes' arms to recover. Their skill levels will then be considerably impaired, and not just because of fatigue. In short, athletes need to engage in a warm-down including a skilled activity—otherwise their strength training efforts could prove counterproductive to maintaining desired skill levels.

Often, if young athletes appear slow, they are labeled as such and made distance runners. Too often these athletes will thereafter compete only in the distance events. Many are naturally reluctant to venture into events where they have less proficiency. Moreover, their coach may see ten points stamped on the shorts of the athletes with respect to the distance events in every dual meet, and so little or nothing is done to develop their basic speed ability. A self-fulfilling prophecy! Some individuals do have less athletic ability, but this should not confuse the issue, as talented distance runners are not slow by layman's standards. They do not have

the speed to become world-class sprinters, but that does not preclude, for example, male middle distance runners from running 100 meters under 11 seconds, and 400 meters in under 47 seconds.

Some athletes are naturally faster or slower in terms of their neuromuscular function and coordination, but that does not mean nature cannot be taught. Slow is sometimes a state of mind, and may reflect an individual's level of excitement. In a life-threatening situation, self-preservation can override learned inhibitions. Take a so-called slow athlete, and also a fast athlete, and sit them down on a piano bench. Observe how well they can perform the scale or a trill. If the slow athlete has years of piano over the fast athlete you could be in for a surprise! And so an athlete's speed ability is in part an acquired skill. It can be learned through repetition and practice. Just as in playing the piano, it requires an investment of time. Not many are Mozarts. Athletes must train speed to have speed, or they will be overtaken by someone more talented, or perhaps more diligent.

Again, speed flows from strength. The great mistake middle and distance runners can make is to neglect strength training because of the degree it can suppress performance when they are in the midst of hard training. Seeing the immediate effect on performance, coaches and athletes might think it bad (just as they might think more and more sharpening work is good). Granted, strength training must be done prudently to avoid adverse effects on the larger training program and performance. Hill work can normally suppress performance by two seconds/400 meters, and adding weight training can put it closer to three full seconds. However, given a properly constructed training program, this two-to-three-second deficit can be translated into a rebound and substantial improvement in performance at the right time and place.

Strength, Durability and Flexibility

Many athletes fear that strength training will hurt their flexibility. It can, when conducted improperly. Anything done improperly can cause problems. But performed correctly, strength training can actually enhance the flexibility of athletes and even reduce their need for stretching. Within certain limitations, stronger muscles have the capacity to be more durable. As a result, athletes will not become as stiff and sore from a given training activity. They will recover faster and require less stretching or therapy to get the kinks out. Strength work can help to restore equilibrium, thus accelerate recovery after a demanding training effort or performance. In short, when it comes to durability the key concept is—*strength saves*.

Flexibility is therefore vitally important to strength and demonstrable speed. Inflexibility is associated with diminished range of motion, and slower performance. Again, tight tendons and muscles send inhibitory messages back through the reflex arcs to protect themselves from overextension and overuse, due to their being under-conditioned. Those messages turn off motor units, resulting in a loss of strength and speed. Moreover, weak muscles in specific regions of an otherwise outstanding range of motion produce muscle imbalances and a condition of dynamic inflexibility. Again, it is one thing to static stretch, but quite another to demonstrate the same range of motion in the practical application. We are concerned

about the running technique of the athletes, not what they look like sprawled out on a gym floor. So an important component of athletic ability is the possession of adequate strength throughout a required range of motion. If athletes have weaknesses or muscle imbalances, then they will normally be more beat-up as the result of distance running. All things being equal, the more efficient their running technique, the less damage will be done. As discussed in Chapter 7, the better movers are dynamically stretching by virtue of superior technique with every stride they take.

Neuromuscular Stereotypes or Habits of Movement

An established, dominant pattern of neuromuscular function is commonly called a neuromuscular stereotype, or habit of movement. We all have them. Try to change the way you walk for just one day and you will appreciate how difficult these habits are to break. It takes time and endless repetition to instill a new neuromuscular stereotype. Every time athletes seek to attain a new level they must break the old habits and build the new. This requires patience and consistency. Take the hurdle event for example. It requires considerable repetition to change some aspect of their technique. And initially, the attempt to instill a new stereotype will likely decrease their skill levels. Later, the athletes will be able to demonstrate the new technique so long as their higher consciousness holds sway. But put them into a competition and often half way through the contest (as conscious control gives way to instinctive and unconscious automatism) the athletes will revert back to their old technique, which at a deeper level is still the dominant neuromuscular stereotype.

Some are able to learn and unlearn neuromuscular stereotypes more readily than others, but expect no miracles. Accurate and immediate feedback provided by video can greatly accelerate the process. Athletes must be careful when engaging in numerous repetitions and sessions, as fatigue can cause them to deviate from the desired technique. Again, there are no practice heats, nor do we ever do anything twice. The competition will be what the training has been. Every time an athlete performs an action, that act is a brick in the wall forming a dominant neuromuscular stereotype. So each and every time you do something, do it with proper technique. That goes for weight training, hurdle drills, or anything else in life. In the realm of philosophy and theology, the analogous concept is known as disposition (as taught by Aristotle, Augustine, and Thomas Aquinas).

To a great degree, an athlete's running technique can reveal self-perception, attitude, mood and the like. It is sometimes necessary to work with an individual at a subconscious level in order to change their technique (Cerutty, 1961). In truth, the coach merely serves as a catalyst, and athletes change themselves. As everywhere else, body language can be important. Consciously or not, experienced athletes can acquire an ability to read the physical and mental status of their competitors. This ability can entail the telegraphing phenomenon well understood in the martial arts (Hyams, 1979). Emil Zatopek, the only man to win the 5,000 meters, 10,000 meters, and marathon events in a single Olympic Games made the following observation (Spear, 1982):

PHOTO 8.3—Emil Zatopek attacks the final straightaway of the 5,000 meters, 1952 Olympic Games. Photo from Hulton / Getty Images.

Question: How do you explain someone like Miruts Yifter of Ethiopia who won the 5,000 and 10,000 at Moscow (1980 Olympic Games) and who may be well over 40?

Zatopek: He is a very nice exception. Not only are his legs an exception, but his brain also. He has a very high intelligence quotient. After the last Olympics he said, "For me it is not so difficult. After five or six laps I have read everyone like a newspaper, and I know who is able to do this or that. And I know what I am able to do." He was able to play with them like a cat with a mouse.

Physical Age, Sex and Level of Development

The body protects itself by conspiracy of nature. It does not acquire much capacity for strength training or respond to it until the growth process has nearly completed. By then the body has sufficiently matured to withstand the stress. Pay attention to nature, since mere chronological age means nothing. It is best to use strength training exercises that employ the athlete's own body weight until the epiphyseal growth plates have settled down and early adult maturity been reached. The years of puberty and rapid skeletal growth should then be limited to introducing proper methods, habits and attitudes relating to strength training.

Pay close attention to nature, since some athletes might be ready at age 16, but others not until age 21. There is no virtue in hurrying things on the creative plane. More athletes have been destroyed by attempting too much too early, than by erring on the side of leniency. Exercise caution in strength training activities, because athletes are especially vulnerable to injury when going through a growth spurt. Note that taller and slighter builds (ectomorphs) tend to mature later than the other body types. Most distance runners roughly fit this description, and as a rule they are later in maturing. It is prudent to record the height, weight and relevant measurements of young athletes and to monitor their physical development quarterly. In this regard, young people are a lot like puppies. Foot size usually arrives before height—so do not use unchanging foot size as an indicator and try to beat the gun. Moreover, adult height arrives before mature body chemistry and physique—thus recognize and respect the sign of the times. When male athletes have nearly reached their adult height (that is, after their growth plates settle down), then they are ready to engage in more demanding weight training.

The same guidelines hold true for female athletes, but their development and maturation is more complicated. With a young man, the maturation process results in a more or less continual improvement in performance. When the maturation process absorbs physical energies, there can be some delays or short-lived plateaus in an athlete's progress. The young woman faces a more trying experience. Initially, she may gain height, strength, and maturity earlier than her male counterpart, and realize radical improvements in performance, perhaps from ages 12 to 15. But then she becomes a woman. Most of the changes that occur are, for the first time, detrimental to her running performance. Indeed, some of the changes could prove to be permanent liabilities, since nature does not intend for many women to become elite distance runners. Do not despair—there *are* other things in life more rewarding!

In any case, the female maturation process typically results in at least a temporary decline in a woman's aerobic ability and athletic performance. Many young women experience metabolic changes that can make weight gain a so-called problem. Women are not ready for serious weight training or otherwise demanding work involving the legs until their hips have fully arrived. Do not push things in this regard, since maturation of the pelvic girdle can result in biomechanical changes that place additional stress on their legs at this time. So perhaps from ages 16 to 18 a young woman will be doing all that she can to hold her ground. The training effort she is putting forth is being absorbed, suppressed or counteracted by the changes occurring in her body. Young women may then encounter a plateau or setback for several years, despite their honest efforts. It can be a tough time for women, emotionally and otherwise. It is important that they clearly understand what is happening, and that expectations are not placed upon them that do not take into account the relevant facts of life. The key is to channel emotional and physical energy in a positive direction. Provided that nature has permitted, after these changes run their course, often a startling leap in performance can follow. Some men might have a hard time understanding why such a fuss is being made. But realize how you might react if for a number of years the changes in your phy-

sique seemed detrimental to your athletic performance. And at the same time, society and most eligible women would be telling you rather loudly and clearly that without those changes you are nobody.

Female structural differences do exist that call for some limitation of intensity and variation in technique with respect to certain weight training exercises. As a rule, women have 30% less strength than men. However, there is little or no difference between the training of men and women at the same athletic level. For example, there is negligible difference in the strength training of a male or female athlete for a 5:00 mile. The training prescriptions would vary more out of individual differences than as a consequence of gender. Simply focus on the athlete and projected goal performance, and work to eliminate areas of weakness.

The years 18 through 25 normally represent the time for optimal strength development. Once attained, athletes can maintain acquired powers with relatively less investment of time and energy, and then concentrate on other tasks. Obviously, athletes can greatly improve their strength levels in later years, especially if they have previously neglected strength development. But in that case, they will have to work a bit harder to achieve the same result. It is important to be as efficient as possible in athletic development, since there is only so much energy and so much time.

Cross-Training

Cross-training is not an extra or alternative activity, but rather a vital component to the athletic skill that distance runners need to acquire. Athletes are not likely to achieve balanced physical development without engaging in some form of cross-training. However, runners should exercise moderation when participating in cross-training activities. The balance of primary to secondary activity and suitability of cross-training activities is of primary importance. It has been suggested that the ratio of primary to secondary athletic activity be on the order: 30/70 for the sprinter, 60/40 for the middle distance athlete, and 80/20 for the marathoner (Cerutty, 1961). That could be pushing things a bit, but the point is well taken. Distance runners should be conducting more cross-training than is common practice today.

Barefoot Running On Natural Surfaces

If athletes have access to a stretch of sand and a dune suitable for training purposes, they should consider themselves lucky and take advantage of it. However, avoid running on a beach with a marked grade or deep sand, and always use moderation when beginning this activity. Unfortunately, sand training and naturalistic technique have been largely ignored in the United States in recent years. Bill Dellinger related that his quantum leap to international caliber came after an extended period of training on the beach (Dellinger and Beres, 1978). This was no mere coincidence. Sand running has figured into the training regime of too many world-class athletes to be ignored. Percy Cerutty's athletes incorporated a great deal of barefoot running in the sand dunes surrounding Portsea, Australia (Cerutty, 1961, 1964, and 1967). Accordingly, this activity figured in the training background of Herb Elliott, former World Record holder in the mile and 1,500 meters, and 1960 Olympic Champion. An article in *Runner's World* similarly revealed another former World Record holder at 1,500 meters, Steve Ovett, running barefoot up a sand

dune (Schneider, 1979). And you can bet that most of the African runners did not sport sneakers on their first training runs. So if you have wondered about sand training, stop wondering about it and start doing it. And if the circumstances and your structure permit, do so barefoot.

Again, begin slowly, and gradually introduce the activity by merely walking in sand for several days—even a few weeks. Athletes can later build up from five to 20 minutes of easy jogging (perhaps during the warm-up and warm-down). Although noticeable positive adaptations can be seen in days, skeletal adaptation alone requires a minimum of five to six weeks before more taxing efforts should be done. So do not think of sand training as a short-term gimmick. As with everything else in distance running, athletes need to make a long-term commitment.

What does sand training do for distance running athletes? For one thing, they can simultaneously stress their cardiovascular and muscular systems to the point of exhaustion at greatly reduced speeds. That cannot be done with such specificity by many other means. It is therefore possible to assume less quantity at lower levels of speed and experience a supra-normal training effect. Running in such an environment also conditions an elusive aspect of an athlete's aerobic ability and anaerobic threshold. Sand training can also enable many forms of work to be performed with less resultant wear and tear on the body. The shock loads associated with running on pavement—and in particular, the punishment normally inflicted by uphills and downhills—is not present. It would actually be difficult for athletes to hurt themselves by running uphill or downhill on sand, whereas the risk of doing so on hard surfaces is high.

The athletes will become stronger and enjoy better muscle balance with naturalistic technique. Many athletes have a tendency to prove themselves to themselves in training, and that often translates into running at high speeds on paved roads. The hardness of the surface returns much of the energy associated with the athletes' footstrike, and the evenness of the surface makes for high levels of efficiency. However, running on grass or other natural terrain can be relatively costly from the standpoint of energy demand, and in this sense, it is uncomfortable. On a natural surface, athletes will often have to work harder, using more of their balancing muscle groups at reduced speeds and with greater mental concentration. That can be beneficial depending on which aspect of aerobic ability is targeted for improvement.

There is also a degree to which conventional athletic shoes inhibit dorsiflexion and plantarflexion of an athlete's foot and toes. The relatively weak plantarflexion and restricted range of motion that many American athletes exhibit relative to the Kenyan distance runners is largely the direct result of Americans pounding their natural technique flat on the asphalt, rather than genetics. If you would like to see how weak your feet are, find two five-gallon buckets and fill them partially with water so they are an effort to handle. Then put on training shoes and climb up 10 steps on stadium bleachers, and return by the same route, carefully stepping down backwards. Repeat this several times, as necessary, while maintaining good form and without spilling anything. Allow a complete recovery. Now remove your shoes and repeat the above process. You might find yourself straining, wobbling and with

PHOTO 8.4—Kenyan children running barefoot to school. Photo from Victah Sailer/Photorun.

an empty bucket before you are finished. Why? Because conventional shoes more widely distribute the forces generated by contact with the underlying support surface, and that is not how it works in nature. Some researchers even argue that the lack of stimuli to proprioceptors in the foot and shoe-shielding from these stressors, can reduce the body's adaptation and level of resistance to injury (Robbins and Gouw, 1990).

Does that mean you should throw your shoes away? No, but it does mean that athletes who condition their feet are wise. Some barefoot jogging on a natural surface in the warm-up and warm-down, whenever circumstances permit, is extremely important. The human body was not made for athletic shoes or asphalt. Those are relatively recent inventions, and the adaptations from these stimuli are not necessarily performance-enhancing. The human body by contrast is a product of the millennia. The most elementary piece of equipment or facility for training purposes would then be a grass track with a two-lane sandbox around the perimeter. The artificial track is an ideal venue for athletic performance, but it is no place for the larger part of training conducted by distance runners.

Cross-Country Skiing

For athletes living in northern latitudes, cross-country skiing can provide a beneficial supplement to running during the winter months. An immediate danger for a runner who is just learning to cross-country ski is a groin pull, and also running into trees! So take precautions and do some flexibility work beforehand in order to avoid the necessity of remedial work later. When athletes resume training for dis-

tance running, another danger is straining their calf muscles. Cross-country skiers are well known to develop the highest aerobic ability of any athletes as a result of the stress placed on their entire body. If athletes think they're fit, they might be shocked by their first experience with cross-country skiing. Even when they do acquire the technique, finding their upper body fatigued and failing could be a new and callusing experience. Nevertheless, the neuromuscular development associated with extensive cross-country skiing is not conducive to performance on the track. The specificity is not there. However, taken in moderate amounts, the strength and power which cross-country skiers develop does translate reasonably well into performance in the 3,000 meters steeplechase.

Indoor use of cross-country skiing equipment can also be helpful—when used in moderation as a supplement, and in particular, to restore equilibrium after demanding running workouts. But beware of extensive use, which might affect your running technique. The posture of the cross-country skier generally has a more pronounced forward lean than that of a runner. Their hands pass more widely at the hip and there is relatively little knee lift. These neuromuscular habits should not supplant those associated with optimal running technique. Accordingly, cross-country skiing can be used as a supplement, but never as a complete substitute for running.

Biking and Swimming

One might think the Almighty intended the bicycle and swimming pool for injured runners—at least this is the conclusion that might be drawn from how runners most often use them! These exercises are sometimes viewed by athletes as activities to keep busy with until they can run again. The time devoted to running is primary, but again, we need to look at running as a skill, and consider how to better integrate various components that contribute to that skill. It is far better to do some supplemental bike or pool training on a regular basis than to become seriously injured—that is to do some "prehabilitation." Biking and swimming can aid in recovery from the demanding running sessions, help to develop strength, and serve to restore balance and equilibrium to the training program. Athletes would do well to conduct some form of alternative exercise such as biking or swimming in one of the two training sessions during active recovery days.

Too much concentration on endurance, like excessive sharpening work, presents a danger, because requisite levels of strength may not be maintained. When athletes conduct a quality endurance or sharpening effort, they expend some measure of their muscular strength and resiliency. Prudent athletes can be found instinctively assuming a bit of strength work after a hard training session or competition. Demanding training sessions or competitions deplete muscular strength and resilience. When athletes make too many withdrawals, they might end up bankrupt, injured, and doing all those so-called "little things" anyway, but now with the possible loss of a season or athletic career. It is a "pay now or pay later" proposition.

If an athlete is incapacitated and requires an extended layoff from running, then pool workouts having the same duration and format as the running sessions can help to maintain aerobic fitness. It is difficult for athletes to get their pulse rate

above 160 bpm in a pool session, but since this approaches their anaerobic threshold, a remarkable degree of the aerobic fitness acquired via their base and strength work can be maintained. However, their local stores of muscle glycogen will normally be depleted when they finally resume running. They will suffer local fatigue and low energy levels for several weeks. When on a time line, athletes might first think the situation hopeless. Do not despair. Keep a cool head and do not attempt too much in trying to get back. The legs will arrive, having had a chance to catch up. Again, all those "little extra" things are not little, nor are they extra. They are a necessary and vital part of the larger skill distance runners need to acquire.

Plyometrics and Circuit Training

The hill bounding advocated by Arthur Lydiard comprises a form of plyometrics. Again, it is best to conduct this bounding technique on forgiving natural surfaces. Figures 8.1 and 8.2 show common examples of bounding and circuit training drills. The substance of plyometrics and circuit training sessions can be easily varied. For other potentially useful plyometric and circuit training programs, see Abmayer and Kosgei, 1992, and Martin and Coe, 1992.

Unfortunately, the potential benefits of plyometrics and circuit training can be easily compromised. Athletes having little or no foundation in strength training should not be introduced to explosive jumping or bounding activities. Runners should not undertake such activities unless they are physically mature young adults who have completed at least two years of consistent strength training. Further, the training loads must be reasonable, and the support surfaces should be forgiving. It is generally better for distance runners to conduct various plyometric drills upon a grass infield, instead of a relatively hard artificial track surface. Moreover, these exercises are best not performed as regimented drills. This method can be appropriate for use with sprinters, or large groups, but it is generally not suitable for use with distance runners. Regimented plyometric exercises can be far removed both physiologically and psychologically—from Herb Elliott leaping with exhilaration in the sand dunes and swimming in the ocean near Portsea. Given a choice, more can be gained by running barefoot on grass during the warm-up and warm-down, than by thirty minutes of bounding in shoes on a mat in a gymnasium. In warm weather conditions, it can be advantageous to play a controlled game of ultimate Frisbee—or non-contact soccer, utilizing a soft ball while running barefoot on grass. When faced with cold winter conditions, athletes can sometimes run barefoot and perform these activities upon an indoor artificial grass surface.

When attempting to restore equilibrium, the goal is to accomplish the required training task while permitting the athletes to physically and mentally recover from the preceding high quality training session. And the best way to do that is to adopt the naturalistic approach and play ethic.

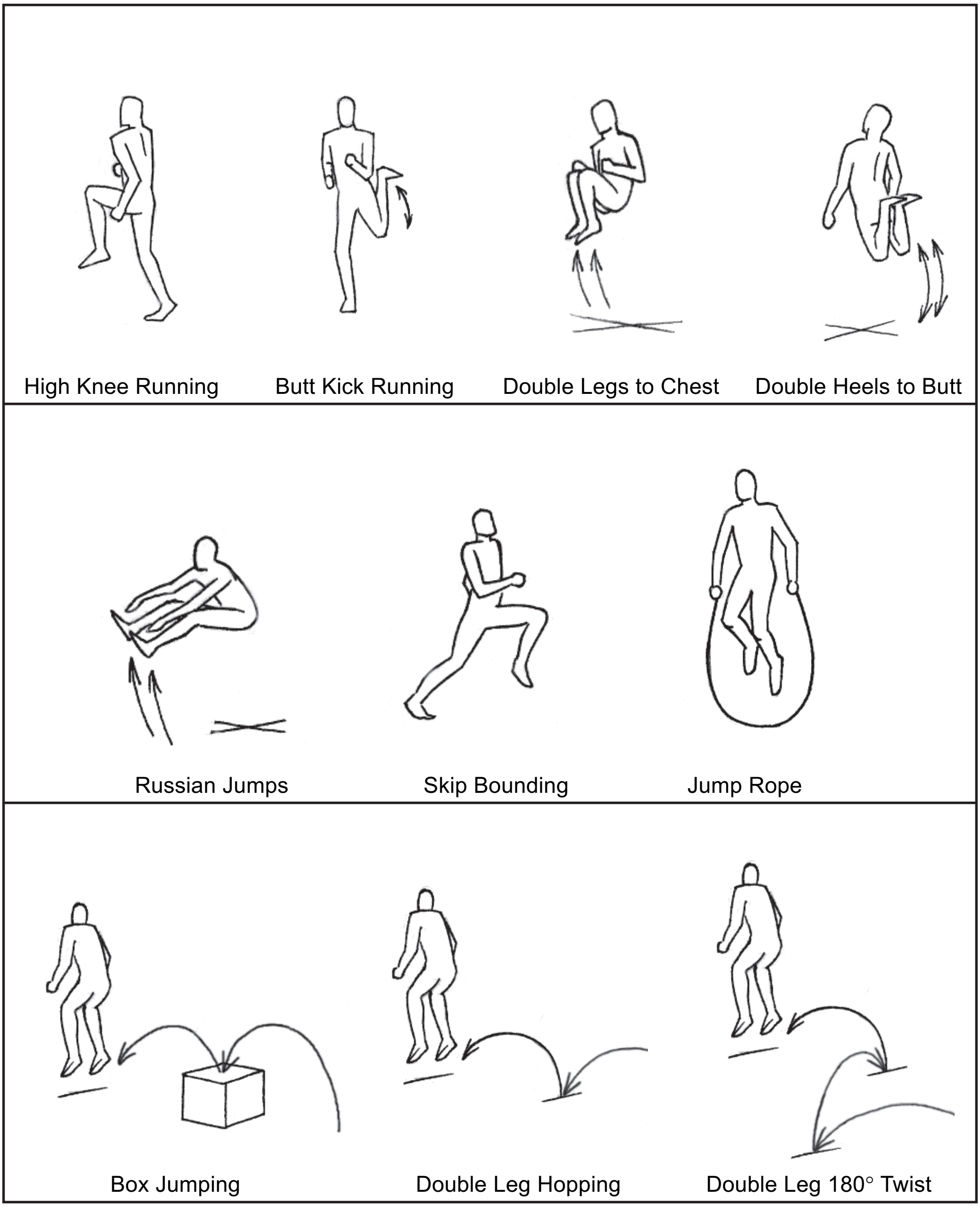

FIGURE 8.1—Plyometric Drills

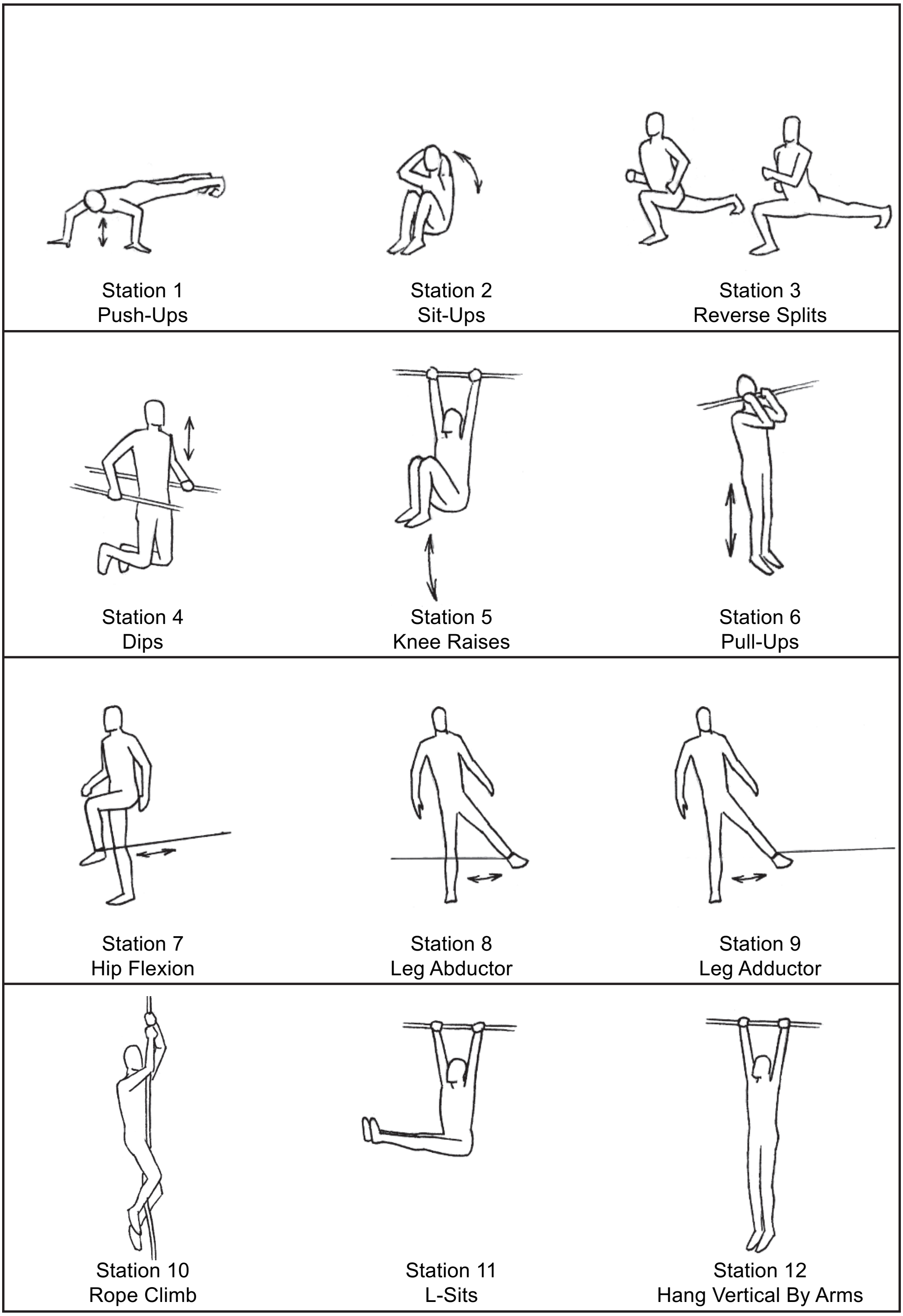

FIGURE 8.2—Circuit Training Drills

Dance, Rhythm, and Coordination

It would be difficult to find a sub 46-second specialist at 400 meters who would not be a superb dancer. The reason being that such performance requires superior neuromuscular control, balance, and coordination. Music and dance are perhaps the best activities for enhancing these qualities. Athletes are advised to participate in dance at some point, since it would both strengthen their feet and enhance flexibility. When athletes appear to be forcing or wrestling with their running technique, the coach might create an opportunity to observe them dancing. The coach may discover that the problem stems from an undeveloped sense of rhythm. However, it could also stem from an effort to maintain full conscious control of their movements—blocking the natural flow of the activity. Miyamoto Musashi, revered by the Japanese as *kensei* or swordsaint, wrote on these matters shortly before passing beyond in the year 1645. It should be noted that Musashi, besides killing over 60 men in individual combat, produced masterpieces of ink painting that are perhaps more highly valued by the Japanese than any other.

> ***Whatever the Way, the master of strategy does not appear fast... skillful people never get out of time, and are always deliberate, and never appear busy. From this example the principle can be seen.***
>
> —Miyamoto Musashi

Job and Work Activity

The late University of Oregon coach Bill Bowerman made a practice of having some of his athletes employed in the sawmills of Eugene, Oregon (Moore, 1992). And under coach Bill Dellinger, the late Steve Prefontaine spent his summers working the docks in Coos Bay. Obviously an individual's employment, whether it be seasonal or year round, should not be such as to impair athletic development. But what Bowerman's athletes did certainly did not hurt them—quite the contrary. One school of thought would suggest that athletes must devote 24 hours of the day to athletics, and have the finest facilities, regimented training, and so on—*ad infinitum*.

However, there is no better way to develop strength than physical work that employs the entire body. Much can be said for a few summer months applied to the well-rounded approach to strength development found in the honest farm-boy or farm-girl ethic. So do not avoid the opportunity if it presents itself. If an athlete has a choice between two to three weight-training sessions a week, or helping someone build a house, well, help build the house! In so doing, you will spend more time engaged in countless reps that will be more beneficial all around. Murray Halberg of New Zealand, the 1960 Olympic Champion at 5,000 meters, once worked during the summer installing fence posts as a way of strengthening himself, despite having a crippled left arm.

Some coaches openly question whether athletes drawn from middle class suburbia possess the mettle required for world-class achievement. And it is easy for athletes on a scholarship stipend to think they are hard working, dedicated individuals on a holy quest for athletic excellence. An occasional eight-hour day of boring work is a good antidote for that attitude. Moreover, it will provide them with perspective, and keep their will to excel in athletics and future career high. It is easy for Americans to become runaholics, because we tend to worship number one and then wrongly equate the measure of an individual with their athletic performance on a given day. That is a lot of nonsense. Most of those who want to accomplish something in this world work hard at thankless tasks and enjoy no fanfare for their toil. On occasion, young people should be reminded of this.

The Principle of Equilibrium

Speed, strength and endurance are as three corners of a triangle that must be balanced upon a central point of equilibrium. To maximize performance on a given day, it is most productive to emphasize one or another of the above aspects at various times in training. Nevertheless, equilibrium between these components must be continually maintained. Again, imagine the athletes' endurance, speed, and strength as three corners of a triangle with the center being balanced on the head of a pin. When they try to raise one corner of the triangle, the other two will be lowered. When they raise two corners of the triangle together, one corner is lowered. In short, it is difficult to raise all three corners simultaneously (Bompa, 1994).

Another way of explaining this phenomenon is by using the analogy of a bank. If athletes attempt to purchase Endurance X, they pay for it in terms of a direct cost, but also an opportunity cost associated with the commodities, Speed Y and Strength Z. For example, when athletes run an endurance training session (such as a steady state run), making a deposit into the endurance bank account, they simultaneously make a withdrawal from their speed and strength bank accounts. A speed training session will normally cause a withdrawal from their strength and endurance accounts. And strength training normally results in a withdrawal from their endurance and speed accounts. Obviously, the various training effects of most activities do not fall neatly into a single category. Nevertheless, this analogy illustrates the interrelationship of the major assets in the "Bank of Athletic Fitness."

When athletes do not observe and implement the principle of equilibrium, they risk unbalanced development, illness, and injury. Repeated withdrawals from the strength account due to demanding running workouts, can easily lead to bankruptcy in the form of an injury. There is also a real danger of developing muscle imbalances when athletes conduct a great deal of endurance work on paved roads. The smooth and rigid nature of the surface provides a level of efficiency not found when running on a natural surface. And the paved surfaces do not permit the athletes to extensively work their balancing muscle groups. They can run faster workouts on paved surfaces, but if the object of the training is to cultivate endurance, it makes more sense to seek out natural grass, sand, or dirt roads. Athletes can then place a higher training load on their cardiovascular system at lower speeds, saving

themselves wear and tear. In addition, natural surfaces impart less shock loading than paved surfaces. Moreover, the inherent strength demanded for running on natural surfaces permits athletes to maintain equilibrium without needing as much supplementary strength work.

When athletes finish a demanding aerobic effort (such as an anaerobic threshold or steady state session), the last thing they will want to do, given the feelings of the moment, is to engage in a 1/4-effort strength training session. But subjective feelings are deceiving, and *this* is precisely what they *will* need to do in order to restore equilibrium. What this entails is first conducting a warm-up set, then a second set with a training load no greater than the first set commonly used in the acquisitive strength training session. Half way through this recovery strength training session, athletes commonly feel unusually refreshed, and the fatigue which normally lingers after a demanding running workout will dissipate.

It is well known that distance running tends to shift an athlete's biochemistry towards catabolism, as opposed to anabolism. An athlete's metabolism should not continue in a catabolic mode long after a run. This would undermine the process of adaptation and acquisition. After a hard training session, it will help to stop further catabolism and promote anabolism if athletes ingest water, but also a citrus juice including a simple sugar such as pineapple-grapefruit. Carrot juice also works well. Alternatively, other forms of sugar also have this effect, such as glucose, sucrose, maltodextrin, honey or foods having a high glycemic index. Getting adequate rest and sleep also promotes anabolism and acquisition, thus athletes would be prudent to take an afternoon siesta, and get to bed at a reasonable hour. However, the important point here is that strength training can dramatically shift the metabolism of athletes from catabolism to anabolism.

Let's return to the earlier analogy in which the triangle of athletic fitness (endurance, speed, and strength) lies balanced on the head of a pin. When athletes first raise the corner of endurance, this causes the strength and speed corners to lower. Then, by conducting a recovery strength training session, the athletes can elevate the corner of strength to an equal position relative to endurance. Nevertheless, this still leaves the speed corner flagging. One of the most noticeable and potentially dangerous characteristics can be a loss of elasticity in connective tissue. After a demanding running workout, athletes can experience tightness, weakness, and a brittle feeling in connective tissues—particularly in their tendons. In short, the snap has substantially gone out of their legs. Accordingly, after a demanding running workout and before the next, it is prudent to solicit the return of elasticity to their connective tissue.

During the warm-down, when conditions permit, barefoot walking and jogging on a natural grass or sand surface can go far to restore the flagging speed corner and equilibrium. Obviously, the surface must be free of glass or other possible hazards. Swimming can also be especially effective. Both of these activities permit athletes to be grounded. A trampoline, or alternatively, a miniature trampoline or so-called rebounder can also be used to good effect. Music and aerobics, or dance activities associated with lateral movements can also facilitate recovery. Depend-

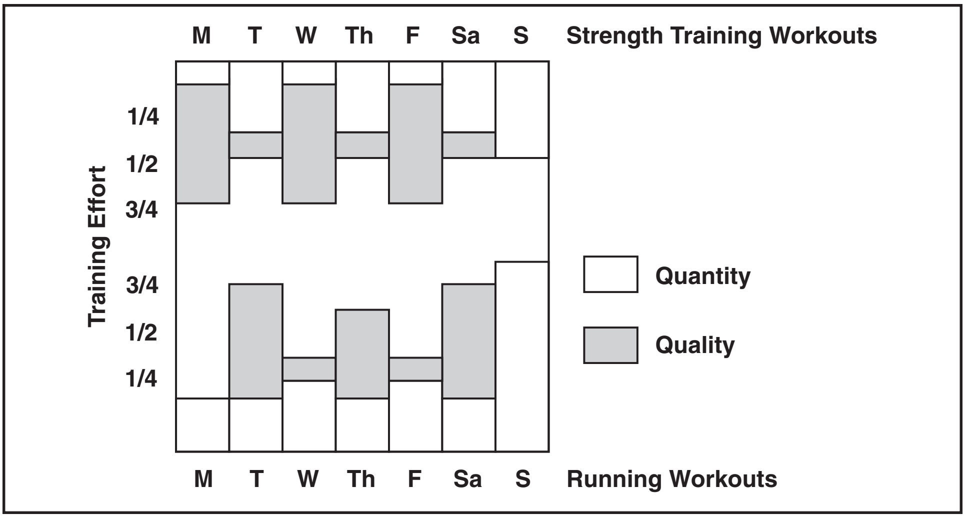

FIGURE 8.3—Integration of running and strength training workouts

ing upon which corner of the triangle had been stressed, other activities might be done in order to restore equilibrium. However, these activities should be as natural, spontaneous, and rhythmic as possible. Psychologically, this means they should correspond to active play.

Strength Training Schedules

Strength exercises often place training loads on multiple parts of the body, but here these exercises will be divided by their primary focus into upper body, abdominal, and lower body groups. In addition, these sessions will be further characterized by their express training purpose:

- Acquisitive efforts—increase strength levels
- Consolidative efforts—stabilize the gains made by acquisitive efforts
- Maintenance efforts—hold on to acquired strength levels
- Recovery efforts—use strength training to restore equilibrium

In no way should weight training compromise the running workouts—which are of primary importance. This means that adequate separation between succeeding weight training and running sessions should be provided to eliminate any counterproductive interaction. Thus, the structure of the weekly running program largely dictates the frequency and magnitude of the weight training sessions that will be assumed. The micro-cycle or weekly training schedule provided in Chapter 1 has been adapted for present use and shown in Figure 8.3.

The timing and interaction between the quality weight training and running sessions is critical, given:

- The positive role of strength training in restoring equilibrium and enhancing recovery
- The negative effects that would attend an improper integration of weight training and the running sessions

Base Period Strength Training Schedule For Workweeks

Monday: Acquisitive upper and lower body strength training session before the passive recovery running workout

Tuesday: Recovery upper and lower body strength training session after the 3/4-effort running workout

Wednesday: Acquisitive upper and lower body strength training session before the active recovery running workout

Thursday: Recovery upper and lower body strength training session after the 1/2-effort running workout

Friday: Acquisitive upper and lower body strength session before the active recovery running workout

Saturday: Recovery upper and lower body strength training session after the 3/4-effort running workout

Sunday: Recovery upper and lower body strength training session after the easy long run

This schedule would provide ample opportunity to conduct three acquisitive weight training sessions, as well as three to four recovery efforts during each workweek. The *early-cycle* and *mid-cycle* weight training progressions would then be used (See Table 8.3). The schedule provided below corresponds to worthwhile breaks during the base period.

Base Period Strength Training Schedule For Worthwhile Breaks

Monday: Upper and lower body strength training performance evaluation before the passive recovery running workout

Tuesday: Recovery upper and lower body strength training session after the time trial or date pace running workout

Wednesday: Recovery lower body strength training session after active recovery running workout

Thursday: No strength training, easy recovery running workout

Friday: No strength training, Day Before Race running workout

Saturday: Recovery upper and lower body strength training session after the control run, time trial, or race

Sunday: No strength training, easy long run

This schedule includes a strength training performance evaluation on Monday, that is, five days prior to a control run, time trial or race. In this way, no counterproductive interactive effects will be experienced. As shown in Table 8.3, the *late cycle* weight training progression would be conducted during this strength training performance evaluation. Throughout the base period, the strength training undertaken largely comprises general conditioning exercises.

After completing the base period, athletes will begin the hill period, which is characterized by more extensive anaerobic work and specific conditioning exercises, both on and off the track. The acquisitive strength training session is then dropped from the schedule, since at least one running workout normally entails strength conditioning during the hill period.

Hill Period Strength Training Schedule For Workweeks

Monday: Acquisitive upper and lower body strength training session before the passive recovery running workout

Tuesday: Recovery upper and lower body strength training session after the 3/4-effort running workout

Wednesday: Maintenance upper and lower body strength training session, body weight exercises being preferred, before the active recovery running workout

Thursday: Recovery upper and lower body strength training session after the 1/2-effort running workout

Friday: Acquisitive upper and lower body strength training session before the active recovery running workout

Saturday: Recovery upper and lower body strength training session after the 3/4-effort running workout

Sunday: Recovery upper and lower body strength training session after the easy long run

This schedule would provide ample opportunity to conduct two acquisitive weight training sessions, one maintenance effort using body weight exercises, and three to four recovery efforts during each workweek. The *early-cycle* and *mid-cycle* weight training progression would then be used (See Table 8.3).

Hill Period Strength Training Schedule For Worthwhile Breaks

Monday: Upper and lower body strength training performance evaluation before the passive recovery running workout

Tuesday: Recovery upper and lower body strength training session after the time trial or date pace running workout

Wednesday: Recovery lower body strength training session after the active recovery running workout

Thursday: No strength training, easy recovery running workout

Friday: No strength training, Day Before Race running workout

Saturday: Recovery upper and lower body strength training session after the control run, time trial, or race

Sunday: No strength training, easy long run